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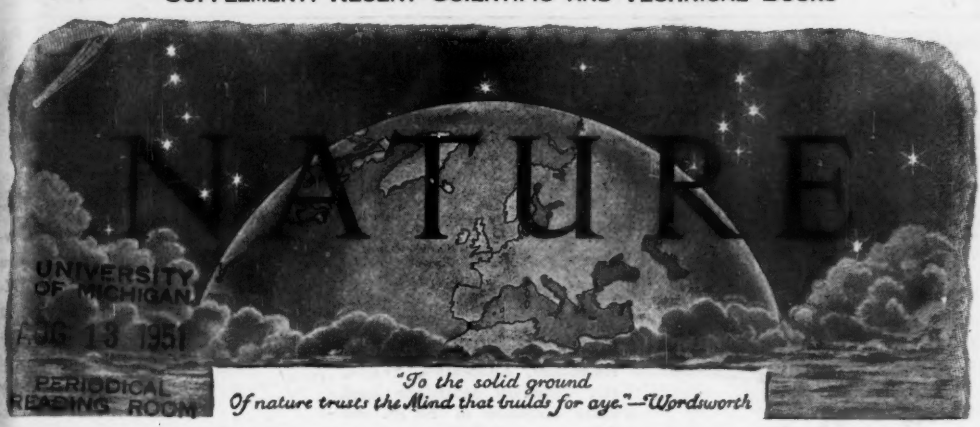

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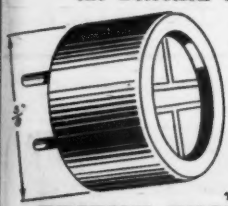

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EDUCATION AND INDUSTRIAL EFFICIENCY

In a paper on the strategy of industrial research, read before the Midlands Section of the Oil and Colour Chemists' Association last November (see *J. Oil Col. Chemists' Assoc.*, 34, 234; 1951), Mr. M. H. M. Arnold maintained that, in spite of the expansion of effort in industrial research in Great Britain during the past thirty years from very few up to tens of thousands of persons, of whom probably 5,000 are science graduates, with few exceptions British industry as a whole has shown little change in the past twenty or thirty years. He said that few firms could attribute their commercial success to their research departments, and that the position of the average research department, in authority, status and financial endowment, is low. He attributed this unsatisfactory position mainly to lack of an integrated approach to industrial problems. There is, he said, a false cleavage, largely traditional, between scientific, technical and economic aspects. He does not think that the size of a firm is often a decisive factor in success in research, except with very small firms; but he argued strongly for greater receptivity to new, and especially speculative, ideas, and also for greater care in general economic and technical appreciation before undertaking any expensive experimental work. In particular, he is sceptical about the value of research directed towards improving a craft process: in that field he believes that progress can only come by bulk production.

While the main thesis that industrial achievement in Great Britain compares poorly with our achievements in academic research is scarcely open to challenge, Mr. Arnold's analysis was not without critics during the ensuing discussion. If, however, he overstressed some of his points, his protest against waste of scientific man-power on work that is intrinsically unlikely to be profitable should be taken seriously. In essence, it strengthens the case argued elsewhere for strengthening the scientific and technical information services at the disposal of industry.

It would not appear from the examination of the three years experience of their working recently made by *Planning* (PEP Broadsheet No. 326) that the four development councils created under the Industrial Organization and Development Act of 1947 have contributed appreciably towards improving industrial efficiency, or linking industry more closely with the public it serves. Objections to such statutory bodies do not, indeed, appear to extend to statutory levies for research; but the inquiry made by PEP affords little evidence that either statutory or voluntary councils of this type are likely to make any real contribution to industrial development. The Cotton Board is an exception in that it is acknowledged, on the whole willingly, by the cotton industry and exerts a considerable persuasive influence there. However, PEP comments frankly that, even so far as the pooling of experience is concerned and the bringing of the least efficient firms up to the level of the more efficient, it is still uncertain that a development council is the best type

of body for carrying out the changes that may be needed.

The decisive factor in industrial efficiency and in industrial research alike is that of leadership, of the supply of scientific workers, technologists and administrators of sound judgment, wide outlook and understanding, capable of selecting the right targets and organizing efficiently. As the Percy Report observed in 1945, the failure to secure the fullest possible application of science to industry is in part a failure in education; this point was stressed independently recently, first by Mr. F. Scholefield, president of the Society of Dyers and Colourists at the Society's annual dinner, and by Sir John Maud in his paper to the Royal Society of Arts on "A Century of British Education". Sir John regards the situation, indeed, as a major problem of British education: however much room there may be for reasonable men to differ about the best means of achieving our goal, the provision for technological education in both university and technical college which we in Britain have inherited must be vastly improved if we are to avoid just and bitter censure from coming generations of our countrymen.

Sir John Maud recognizes that both the universities and the technical colleges have much to contribute: the best universities have their tradition as the common home of science and the arts, research and teaching, of recluses and men of the world, their tradition of independence and inflexible attachment to the highest standards of scholarship; the best technical colleges have an inheritance of intimate association with industry. He said he is confident that we shall find ways both of conserving the peculiar virtues of our various institutions for higher technological education, and, at the same time, of learning from the different experience of the United States, Switzerland, Germany and other countries. Dr. C. J. T. Cronshaw, at the Society of Dyers and Colourists' annual dinner, spoke no less confidently on this point; but he also insisted that a first-class technologist must be also a first-class scientist: arbitrary division between science and technology, he said, is unwise, and he thinks the only method of training technologists is to train scientific men and give them, within the industry itself, the opportunity to become technologists.

Mr. Scholefield, while accepting as justified Dr. Cronshaw's emphasis on the importance of science, inclined to support the view that alternative methods of training technologists are also possible. The divergence between the two views would doubtless be clarified if the meanings of the terms used by the speakers were defined precisely, and particularly exactly what is meant by 'technology'. There are obvious limits to the extent to which technology in the sense of day-to-day practice can be learnt anywhere except in the industry itself, and Dr. Cronshaw's insistence on the importance of science is in keeping with all that was said at the Home Universities Conference last December as to the qualities for which industry looks first in its recruits from the universities, and the desire for graduates of mature education as distinct from merely high technical ability.

An important part of a liberal education is the knowledge that it conveys to the student, often through the literature and history, of the traditions, ideas and beliefs that prevail in his society. It helps, too, in the formation of sound judgment and in giving due weight to the human qualities to which Dr. D. W. Hill directed particular attention in a paper on the chemist as administrator last October (*J. Roy. Inst. Chem.*, **74**, 447; 1950). Such knowledge and judgment cannot be acquired in the range of technological studies, and in this sense science and technology do not provide a liberal education, as Lord Cherwell and others contend. Even Sir Graham Savage, in an address on the future development of higher technological education to the Union of Educational Institutions on June 8, supported this dubious proposition; though he urged, too, that industry can only be efficient if it is manned and directed by a staff in which highly trained and efficient technologists are fully represented.

Sir Graham appeared to be thinking primarily of the receptivity of industry to new scientific and technical ideas; but how essential such humane knowledge and judgment are to anyone who aspires to play a leading part, even as technologist, in the world to-day, can scarcely be better demonstrated than in the study of the composition of the boards of nationalized industries which the Acton Society Trust has just issued under the title "The Men on the Boards"*. This pamphlet disposes effectively of the wilder charges against members of the boards, and indeed gives a firm rebuke to those who make unfounded charges; but it indicates that, by and large, failure has occurred just at this point.

Members of national boards have been chosen simply for their ability and experience in industrial and administrative affairs, and it is manifest that business ability is not enough. Ignoring factors peculiar to single boards, the general review leads to the conclusion that national boards have not succeeded to any marked extent in dispelling the traditional suspicions of employees and in opening up an era of harmonious co-operation. Sometimes they have failed to raise important topics for consultation until after decisions have been made; and again, requests from the employee side to discuss certain matters have been rejected out of hand. Some boards have taken a narrow view of their responsibilities in such matters as the provision of training and research, and have been reluctant to experiment in this field. Training programmes have frequently been limited in scope and have ignored the need for giving the employee a wider knowledge of the structure of his industry and his responsibilities as a citizen in that context.

Again, there is evidence that the boards have failed to appreciate the unique character of the task of running an entire industry on a monopolistic basis, and of the need for working out fresh solutions for the completely new set of organizational problems which arise. They have not always shown the imaginative approach and willingness to experiment with new

* The Men on the Boards: a Study of the Composition of the Boards of Nationalised Industry. (Nationalised Industry Series, 4.) Pp. iii+22 (Claygate: Acton Society Trust, 1951.) 2*s*.

patterns of organization and communication for which the situation calls. In general, they have also been reluctant to explain themselves to the public.

For such reasons the Acton Society Trust suggests that what is required is a trustee board composed of people of many types of ability, and selected particularly for their imagination, adaptability and breadth of vision. They must be competent to take the review of wide issues which is an essential part of their duties. Equally, the organization must provide for more effective contact with employees.

In this study there are no illusions as to the difficulty of obtaining a sufficient range of experience for the task; and the suggestion is advanced that a small permanent commission, with a qualified staff, should be constituted for appointing members to the public boards. But one of the important features of this study is the implication it has for other fields. Part of the responsibility for the failure of the national boards lies clearly on the inability of the trade unions themselves to provide men from their membership of the necessary vision and judgment. The very growth in power of the trade unions makes the question of wise leadership for them a national and not a sectional issue; yet at the same time the series of sporadic unofficial strikes have emphasized the inherent weakness of their present organization.

It is in such a context as this that the question not merely of higher technological education but also of higher education generally, whether full-time or extra-mural, needs to be considered. It is not a question of selecting and training men or women specifically for leadership. It is rather one of providing the education which will ensure that those called to positions of responsibility in any walk of life are so equipped that they can bring to their task, not merely technical or scientific knowledge and practical experience, but also wide vision and the understanding of the human issues which will prevent sectional from prevailing over national interests. Only men and women so equipped are capable of the clear and balanced thinking which is required both in handling the problems of organization and policy in undertakings of the scale of nationalized industry, and in the selection of the right targets for research and development.

AUSTRALIAN GEOLOGY: A REGIONAL SYNTHESIS

The Geology of the Commonwealth of Australia
By the late Sir T. W. Edgeworth David. Edited and much supplemented by Dr. W. R. Browne. Vol. 1. Pp. xx+747+58 plates. Vol. 2. Pp. iv+618+plates 59–84. Vol. 3. 5 maps. (London: Edward Arnold and Co., 1950.) 3 vols., £12 12*s*. 0*d*. net.

THESE volumes, unequalled among regional surveys of comparable dimension for their scope and range of completeness, mark a major event in the annals of Australian geology and form a fitting monument to the memory of Sir Edgeworth David, their chief architect. For this stupendous undertaking, begun a quarter of a century ago and now at last brought to completion, no one was so fitted as Sir Edgeworth David himself. His own personal researches had covered an amazingly wide field embracing geological problems in every State of the Commonwealth, and he had, through half a century, made himself familiar by extended travel with the field-work of his colleagues in every corner of the continent of Australia.

As the first product of Sir Edgeworth David's labours a large coloured geological map of the Commonwealth on a scale of 1 : 2,990,000, together with a slender volume of explanatory notes, had been issued in 1932. The book itself, however, remained unfinished at the time of his death in 1934 and the task of completing it fell to his colleague, Dr. W. R. Browne. The long delay in its appearance has been due in part to the Second World War, when publication proved impossible, and to the further revision which was deemed advisable at its close, to bring the manuscript so far as possible abreast of the more recent advances. This revision has, in fact, involved rewriting part of the original text, and geologists owe Dr. Browne a debt of gratitude for his unselfish devotion to a labour which must have been beset by many difficulties.

The book is in three volumes: the first, of 747 pages, deals with historical geology, including a chapter on the geology of Australian New Guinea, while the second (618 pp.) treats of the physiography and economic geology. The third volume contains the coloured geological map issued in 1932 together with a map of Australian New Guinea (1 : 2,500,000) which, though previously published by the Directorate of Army Research, had not become generally available.

The pattern of treatment in the section on historical geology is the description of the formations by States, each chapter presenting a geological distribution map of the period and concluding with an extensive bibliography.

The final chapter of the first volume attempts a review of the tectonic history of the continent of Australia, considering its relations with Asia, the framework within or about which it was built and the events leading up to its present isolation.

The main impression given by these volumes is one of great completeness, of a story which has not only summarized the whole wealth of published data but has also essayed to provide the vitalizing threads of synthesis. Occupying as they do not less than one-sixth of the area of the continent and forming the repositories of leading ore deposits, Pre-Cambrian formations come to play a major part in Australian geology. Their description covers a hundred pages of the first volume, and the geology of their economic products is lucidly discussed in many chapters of Volume 2.

The correlation of the various divisions of this vast Pre-Cambrian terrain is beset with intricate problems and, as might be expected, stratigraphic and structural knowledge of the more complex areas is best known from centres of active mining. It is clear from these accounts that in Australia, as elsewhere, an immense field of research on the older rocks lies open to the investigator.

An admirable description is given of the widespread Upper Pre-Cambrian series, which holds a major glacial horizon and appears to pass in many places conformably into fossiliferous Cambrian, thus suggesting that parts of the series are Lipalian in the

sense of Walcott, bridging the time between the Pre-Cambrian and the Palæozoic.

During much of Palæozoic time and later, the Australian continent is pictured as bounded east and west by geosynclines.

In particular, the attention of the reader is arrested by the account of the great tectonic depression known (and so named by Schuchert) as the Tasman geosyncline, covering at various times much of eastern Australia and Tasmania. The synthesis of events that gave growth and change to this majestic structure forms a central theme in the discussions of the Palæozoic System, and the detailed account of its structure, its repeated orogenies and synchronous or subsequent granitic epochs form one of the most fascinating sections of the book.

The magnificent vista thus skilfully revealed will give added stimulus to the prosecution of major groups of researches, providing, for decades to come, lines of investigation for workers in all departments of the science.

In the long geological history of Australia so clearly depicted, it is pleasing to find that measured emphasis is given to the place of vulcanism and plutonic igneous activity, with an attempted assessment of their role in the stratigraphic and tectonic record. Knowledge of the vulcanicity is perhaps most detailed among the Tertiary lava floods of eastern Australia, where petrological investigation has been more intensively carried forward. The book is enriched by an up-to-date chapter on Australian New Guinea prepared by officers of the Australasian Petroleum Co. One of the more interesting disclosures emerging from recent study of this region, and here recounted, is the refutation of the long current interpretation of the occurrence of over-thrusts of Alpine type among the younger folded rocks; on the contrary, the mountain-building movements are now recognized as being primarily vertical rather than horizontal.

The section on physiography, a work of 141 pages in the second volume, provides an exemplary account of the main features of the geomorphology of the continent of Australia. The larger section of the volume, however, is devoted to economic geology, commencing with a general account of the distribution of ores in space and time and their close relation to the epochs of plutonic intrusion.

Thereafter each of the chief metals is described in chapters divided by States. Important sections deal with coal, lignite and oil shale, and the descriptions conclude with a survey of artesian basins which cover in the aggregate upwards of one-third of the area of Australia, the largest in regions of low rainfall. The results of the prolonged study of these basins, the problems of their stratigraphy, structure and chief aquifers, and of the flow and salinity of their waters, are very completely set out with copious reference to the extensive researches devoted to this field. Many other fascinating topics, which in the limits of a short review it is impossible adequately to consider, are lucidly expounded in this monumental treatise.

Here will be found the discussion of such diverse subjects as the evidence for no less than five ancient glaciations, three of them of major extent and duration; the nature of the correspondence between recorded diastrophisms and those of extra-Australian regions; the rise and extinction of the distinctive land flora of the Carboniferous and the controversial problem of the Permian boundary; the status of the Papuan geosyncline; the disruption of the Australasian continent; and the antiquity of man.

The topics are legion, and it would appear that no significant study devoted to the regional geology has escaped summary. The book without doubt will endure as the chief reference work on Australian geology for many years. In the concluding sentence of the introduction the study is described—and well described—as at once a stocktaking and an interpretation. That it also forms a secure foundation on which the student of to-morrow may build Dr. Browne may be emphatically assured, and can proudly so claim. The impressive work marks, indeed, a vantage point in the history of advance in regional geology with which the names of David and Browne will always be associated. C. E. Tilley

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THE TEACHING OF COLLOID CHEMISTRY

Kurzes Lehrbuch der Kolloidchemie

Von Dr. B. Jirgensons und Dr. M. Straumanis. Pp. viii+282. (Berlin, Göttingen und Heidelberg: Springer-Verlag, 1949.) 21.60 D. marks.

THE importance of a sound knowledge of colloid science to the chemical technologist has resulted in more attention being paid to this subject in university courses in recent years. A number of excellent monographs and larger volumes aimed mainly at the already trained worker exist, but there are few treatments written frankly for the student. This compact work by Drs. B. Jirgensons and M. Straumanis is therefore welcome. It is unpretentious: it is a university text-book and nothing more, but it is a good one. The authors have known what to leave out as well as what to put in. The student is guided logically through what can be pedagogically an awkward subject, and the introduction to modern physical techniques comes early. This is a good point, as it is unwise to overload the new student with all the classical burden; it is better to present him early on with a sound framework into which he can fit further facts and observations as he comes across them.

The descriptions of experimental techniques are of just the right standard: the main features and underlying theory are given, and the reader is guided to the essential literature. In a second edition, the opportunity might be taken to include a short section on the low-angle X-ray scattering method for particle-size determination in the 100-A. range. At the same time, the section on the X-ray line-broadening method could be slightly amplified to cover the intensive discussions on this subject which occurred in Great Britain during the war years.

As might be expected, the book to some extent reflects the barrier of the war period. This could easily be remedied in a new edition which, while broadened to embrace recent American and British advances, should not lose the present book's high quality of presentation. In my opinion, this short book of some 280 pages would be well worth translating into English for the benefit of the many students who find difficulty in reading German. It does not compete with recent larger works which can give a much fuller and more thorough treatment than is attempted by Jirgensons and Straumanis. Its attractive features are its succinctness, its wise selection of material and the exceptional clarity of treatment. D. P. Riley

SCIENCE AND TECHNOLOGY OF POWDER METALLURGY

Treatise on Powder Metallurgy

By Dr. Claus G. Goetzel. Vol. 1: Technology of Metal Powders and their Products. Pp. xxvii+778. 90*s*. Vol. 2: Applied and Physical Powder Metallurgy. Pp. xviii+910. 144*s*. (New York and London: Interscience Publishers, Inc., 1949–50.)

COMPARATIVELY little is generally known of the increasingly important part played by the products of powder metallurgy in industry. Possibly the publication of this encyclopædic treatise on the subject may conduce to a wider knowledge of the subject, especially in engineering circles. Powder metallurgy is defined as the art of producing metal powders and objects shaped from individual, mixed or alloyed metal powders, with or without the inclusion of non-metallic constituents, by pressing or moulding objects which may be simultaneously or afterwards heated to produce a coherent mass, either without fusion or with fusion of a low-melting constituent only.

The earliest products on a commercial scale were porous oil-impregnated bearings of bronze. To-day the most important materials produced are cemented carbide tools which in a few years have revolutionized the operations of cutting, grinding, machining and milling, and have accelerated production and effected economies beyond any expectation of engineer or manufacturer; at the same time the products of powder metallurgy have suggested solutions to many outstanding problems in the production of high-temperature resistant materials, to mention only one group of potentialities.

The Second World War enormously accelerated progress in every department of powder metallurgy, and workers therein have felt the lack of any comprehensive survey which would correlate theory and practice and at the same time attempt an over-all picture of the development and progress which have been so notable a feature of the past decade. The two volumes by Dr. C. G. Goetzel most admirably fill that void. Vol. 1 covers the technology of the processes of the art, discusses the underlying principles and provides a historical review. Methods of powder production and the characteristics and properties of powders are discussed in detail. Methods of testing powders are described, and attention is given to the widest range of commercial powders. The behaviour of powders under pressure and the moulding of powders into solid form are dealt with, followed by a discussion of dies, punches, presses, and, after consideration of hot pressing, the principles of sintering and its practice, including furnaces and atmospheres as well as finishing treatments. Vol. 2, divided into two parts, deals first with applied powder metallurgy and supplies the fullest account extant of the happenings and progress of the past ten years. The sections cover refractory metals and alloys, hard metals and compositions, electrical and magnetic materials, ferrous and non-ferrous materials for structural parts, porous products, friction materials and dental alloys. The second half of the volume, on physical powder metallurgy, describes and discusses the important phases of the physical metallurgy of metal powders, comparing the physical properties of sintered and fused industrial alloys and metals. An excellent survey is given of sintered metals and alloys for potential industrial use; the stress analysis of sintered metal structure and an appraisal of testing methods provide material of outstanding practical value, while there is a full and most useful review of theories of bonding and sintering.

A section is devoted to the future of powder metallurgy, and it is perhaps the future that should be stressed, for no other technique has such potentialities or holds out such promise as powder metallurgy. Not only does it overcome the handicaps that are inherent in the limitations imposed by the necessity for melting and then cooling-down molten metal, but also it overcomes the incompatibilities arising from widely divergent melting points, large variations in electrical or heat conductivity, and the differences between metallic and non-metallic bodies. It can produce unique materials, and these two volumes by Dr. Goetzel provide a guide and a commentary comparable with the best that is available in any other subject. Moreover, the documentation is of a high order and is to be supplemented by a third volume which will comprise a classified and annoted bibliography covering both literature and patents.

H. W. GREENWOOD

OPERATIONAL CALCULUS

Operational Calculus based on the Two-Sided Laplace Integral

By Dr. Balth van der Pol and Dr. H. Bremmer. Pp. xiii+415. (Cambridge: At the University Press, 1950.) 55*s*. net.

ALTHOUGH operational calculus is not derived from anything fundamentally new in mathematics, it is nevertheless a comparatively modern technique. Since its recognition as a valuable weapon, both in pure mathematics and mathematical physics, much literature has appeared, ranging in scope and manner of presentation from the practical text-book to the erudite treatise. In almost all cases where the analytical background has been worked out in detail, the author has adopted one of two main courses: either following Heaviside in using an operator $1/p$ defined as a definite integral; or by using the so-called Laplace transform $\int_0^\infty \exp(-pt)f(t)dt$, or in some instances $p\int_0^\infty \exp(-pt)f(t)dt$. It is not intended here to compare the advantages and disadvantages of these alternatives (which are, of course, mathematically equivalent), but to discuss briefly a third method of attack based on the replacement of the one-sided integral, quoted above, by a two-sided one of similar character, namely, $p\int_{-\infty}^{\infty} \exp(-pt)f(t)dt$.

It is at once clear that this modification of the Laplace transform does not basically affect the ideas and methods of procedure encountered in the one-sided case. We still have, for example, a unique 'image' $\varphi(p)$ derived from the 'original' $f(t)$ by the integral transformation, and a complex inversion-integral enabling us, in certain cases, to determine explicitly the original of a given image. Furthermore, we are still in possession of the fundamental asset of the oper-

ational calculus in that we can study the properties of many apparently quite intractable and often discontinuous functions of a real variable t by means of their smooth, analytic (and therefore much simplified) images in the p-plane. What, therefore, are the advantages of the two-sided transform, and what are its corresponding disadvantages, if any?

Three advantages are summarized by the authors, in their preface, as follows: the class of functions $f(t)$ suited to operational treatment becomes much larger; the transformation 'rules' are considerably simplified; and the entire treatment becomes more rigorous. On the other hand, the disadvantages are mainly of a theoretical kind, being for the most part concerned with the precise stipulation of the strip of convergence $\alpha < \mathbf{R}(p) < \beta$ for which a particular relationship is valid, and are therefore often of little interest or importance to the more practical student. It would seem to be well worth while to illustrate the above remarks by means of actual examples, where possible. Using the symbol $\sim$ for the equivalence of $f(t)$ and $\varphi(p)$, it can easily be shown that $\exp(-\alpha|t|) \sim 2\alpha p/(\alpha^2-p^2)$, while in the one-sided theory there is no proper image. Again, $\exp(-\alpha t^2)$ $(\alpha > 0) \sim \sqrt{(\pi/\alpha)}p \exp(p^2/4\alpha)$ for all p, a much more compact result than the one-sided image $1/2\sqrt{(\pi/\alpha)}p \exp(p^2/4\alpha)$ $\mathrm{erfc}(p/2\sqrt{\alpha})$. Yet another example of a much simplified image is afforded by $1/(1+e^t) \sim -\pi p/\sin \pi p$ instead of one involving logarithmic derivatives of the gamma function. As regards the simplification of the transformation 'rules', one may quote an extremely elegant form of the 'shift' theorem, namely, $f(t+\lambda) \sim \exp(\lambda p)\varphi(p)$ for all real λ, while Borel's 'composition' theorem becomes

$$\frac{1}{p}\,\varphi_1(p)\varphi_2(p) \sim \int_{-\infty}^{\infty} f_1(u)f_2(t-u)du,$$

a valuable improvement on the old form on account of the constant upper limit of integration. There is, admittedly, a compensating difficulty here, in that a common strip of convergence is sometimes not available, but this is easily obviated by use of the 'shift' theorem in the majority of cases. It would be outside the scope of a review to attempt to deal seriously with illustrations of the authors' third contention that the entire treatment becomes more rigorous, and so it must suffice to say that there are numerous places in the text where such illustrations are presented.

The book is divided into sixteen chapters, covering an unusually wide range of 'operational activity', beginning with an introduction by way of the Fourier transform, followed at once by a detailed survey of the elementary 'images' and rules. Special attention is then focused on the Heaviside 'unit' function and its derivative, Dirac's δ or 'impulse' function, both of which play an important part in the two-sided theory. After further chapters concerned with theoretical development, the authors deal very thoroughly with linear differential equations (including those with variable coefficients) and their many applications to electrical circuits, networks and filters.

Many special functions, in particular those of Bessel and Legendre, and the polynomials of Hermite and Laguerre, are then discussed, and there are also chapters dealing with difference equations and integral equations. Finally, we have partial differential equations, both in one variable and several variables, with the introduction of a *simultaneous* operational calculus enabling the reader to study a new treatment of Green's functions, potential theory and Maxwell's electromagnetic equations.

Appendixes are supplied containing a summary of the general rules (aptly described by the authors as the 'grammar') and a classified 'dictionary' of the images of the more familiar functions, all of which is absolutely indispensable to anyone intending to make a systematic use of the operational calculus, either in mathematics or physics.

By way of criticism, it must be pointed out that as the work is a translation from a series of lectures in Dutch, the language is from time to time somewhat clumsy and stilted, and there are even instances in which a wrong word has been used. Such imperfections, however, are of little consequence in a book of this kind, where a large part of the text is purely symbolic. The excellent reproduction has regrettably resulted in a price that may well be outside the range of many an impoverished student, but those whose purse can still rise to the occasion will be amply rewarded by the possession of a copy.

J. H. Pearce

ANIMAL PSYCHOLOGY

Handbook of Psychological Research on the Rat

An Introduction to Animal Psychology. By Norman L. Munn. Pp. xxvi+598. (Boston and New York: Houghton Mifflin Co.; London: George G. Harrap and Co., Ltd., 1950.) 35*s*. net.

A FEW years ago, Dr. N. L. Munn produced a book called "Psychology: The Fundamentals of Human Adjustment". It immediately won its way to high popularity in many universities in the United States and in Great Britain. It is a good general introduction to psychology.

The author's success is likely to be repeated with this new work, particularly if those who recommend it direct attention to its sub-title, which does not appear on the spine or the front cover of the book. It is, indeed, a handbook of psychological research on the rat, with a bibliography of 2,500 references, but it is much more than that: it is a fine, scholarly record of numerous investigations that display clearly the foundations of the psychologist's claims to be a man of science and to be able to make a contribution to science that other scientific workers cannot make. The non-psychologist who seeks a straightforward illustration of this point will find it in the section (pp. 272–278) that deals with studies of 'delayed reaction'.

Although most of the book is taken up with work on sensory and learning processes, about a quarter of it is devoted to 'abnormal and social behaviour'. This is a welcome sign that rat psychologists are throwing off the tendency to narrow-mindedness that for many years has restricted the scope of their investigations and has incidentally deprived many non-laboratory psychologists of the advantages of close contact with them. One notable recent development in this field has been experimentation on the effects of electroconvulsive shock. As Dr. Munn remarks (p. 441): "Although the first study of electroconvulsive shock on rats was published in the present decade, the literature is already extensive and new studies are pouring in". Among the investi-

gators who have become prominent in this area is Dr. Roger W. Russell, formerly of Pittsburgh, who has recently succeeded Sir Cyril Burt as professor of psychology in University College, London.

The summary and conclusions on abnormal behaviour (p. 463) and social behaviour (p. 473) will appeal very much to a wide range of readers, though they tend to give the gloomy impression that rats are on the whole no more regardful of other rats than are human beings of each other. Thus (p. 475): "The clearest instances of what might be regarded as truly cooperative behaviour are those in which two rats learned to take turns in sitting on a platform so that each could feed without receiving an electric shock".

Dr. Munn's italicized postscript (p. 476) gives an excellent indication of the content of his book. "We have seen that the rat is an exceedingly useful tool for the investigation of a wide range of problems having relevance for human psychology. Of especial significance from this standpoint are the findings on: (1) physiological aspects of motivation, (2) contributions of sensory processes in learning, (3) the role of brain processes in learning, retention, and reasoning, (4) effects of drugs and vitamins on the learning process, (5) equivalence of stimul. in perceptual response, (6) evaluation of learning theory, (7) effects of nutritional conditions upon abnormal behaviour, (8) conflict as an etiological factor in behaviour disorders, (9) analysis of the procedures and outcomes of shock therapy and (10) objectification of psychoanalytic mechanisms. In some of these fields the research is well advanced and rather definite conclusions are possible. . . . In others, and particularly the last-mentioned, research is in its initial stages."

ALEC RODGER

BIRDS OF PARADISE AND BOWER BIRDS

Birds of Paradise and Bower Birds

By Tom Iredale. Pp. xii+239+33 plates. (Melbourne: Georgian House Pty., Ltd.; London: Phoenix House, Ltd., 1950.) 105*s*. net.

ON p. 2 of this book there occurs the following pronouncement: "The acme of uselessness in ornamentation appears to have been reached in the Birds of Paradise, as here coloration and feather structure appear in the male, making it a very beautiful creature, while the female has remained very ordinary". It is a minor tragedy that the book, superbly illustrated by Mrs. Iredale (Lilian Medland) and finely produced by its Melbourne publishers, is in its text a hotchpotch of such statements, old-style taxonomy and long and uncritical quotations from the frequently inaccurate accounts of collectors and bird photographers.

The birds of paradise are unrivalled in their epigamic adornments and astonishing in the use they make of them. The bower birds are generally not only of outstanding physical beauty, but also perform complex displays at their bowers and display-grounds to which they bring coloured or shining flowers, berries, leaves, shells and bones. Each species makes its choice according to the hereditary conservatism of its kind. Three species paint the walls of their bowers with various substances. One Australian bower bird actually fashions a tool to help it apply the paint which, in this instance, is a mixture of saliva and charcoal obtained from logs burnt by bush-fires. Another clears a patch of dark jungle floor and covers it with a striking pattern of leaves sawn from neighbouring plants with a remarkable 'toothed' beak that is adapted to the job. Yet in this book no attempt has been made to relate habit and function. Mr. Iredale has steadfastly ignored all the implications of the work of Howard, J. S. Huxley, F. H. A. Marshall, Lorenz and other pioneers who have revolutionized our understanding of the function and physiology of display during the last three decades. Mr. Iredale has likewise largely ignored the opinions of Stresemann, Stonor, Mayr and others who have done so much work on the anatomy and phylogeny of the birds of paradise. He dismisses a little contemptuously the possibility that some of the rare birds, collected and described during the trading days, are the result of natural hybridization. The present reviewer has never been directly concerned with this problem; but he cannot help feeling that it is the careful studies of Meise and Stresemann, rather than the present generalizations, that carry the more weight with the disinterested worker in a neighbouring field.

On the credit side, in addition to the coloured illustrations, typography and binding, there are interesting historical data concerning the legendary attributes of the birds of paradise. Thus, John Huyghen van Linschoten, after a voyage to the East Indies: "In these Ilands onlie is found the bird, which the Portingales call passaros de Sol, that is Fowle of the Sunne, the Italians call it Manu codiatas, and the Latinists, Paradiseas, and by us called Paradice-birdes, for ye beauty of their feathers which passe al other birds; these birds are never seene alive, but being dead they fall on the Ilands: they flie, as is said alwaies into the Sunne, and keepe themselves continually in the ayre, without lighting on the earth, for they have neither feet nor wings, but onlie head and body, and the most part tayle . . .". This legend arose, of course, from the birds' unearthly beauty and because trade-skins (which were bartered from tribe to tribe long before recorded Pacific history) often lacked legs and wings.

Other accounts stated that besides lacking wings and legs, paradise birds also lacked stomachs. But a latter-day sceptic had the following to offer: "It was believed by the credulous and ignorant, the most numerous class of men, that it lived alone upon the air and dew; that it had no intrails, nor feet; but remained perpetually floating upon the air while sleeping, as well as while awake; while hatching and laying as well as while procreating its young. . . . Instead of a stomach and intestines, which, to so extraordinary a feeder, would have been useless, the cavity of its abdomen was said to be filled with fat."

There is also included brief but welcome information concerning the great nineteenth-century travellers A. R. Wallace, D'Albertis, Beccari and Macgregor. But, incredibly, the book has no references and there is no index.

Whatever one's friendship and affection for the author—extending over twenty years—one cannot find in the text much else to praise. It is "as dry as the remainder biscuit after a voyage". Mr. Iredale has indeed strange places crammed with observation—and he has vented it in mangled form.

A. J. MARSHALL

Electromagnetic Theory

By Oliver Heaviside. Complete and unabridged edition of Vol. 1, Vol. 2, and Vol. 3, with a Critical and Historical Introduction by Ernst Weber. Pp. xxx+386. (New York: Dover Publications, Inc.; London: E. and F. N. Spon, Ltd., 1950.) 63*s*.

ADMIRERS of Oliver Heaviside's work will be highly appreciative of the appearance of an unabridged edition in a single volume of his three volumes on "Electromagnetic Theory". In spite of the excellent English in which it is written, Heaviside's work is in general by no means easy to read, and only by patient search and serious study can real benefit be derived from much of it. A major difficulty in the earlier editions was the absence of a detailed index to supplement the tables of contents, and there can be no doubt that this lack accounts for the fact that a number of his important contributions were overlooked for many years. It is unfortunate that this omission has not been repaired in the new edition.

The book is a most attractive reproduction of the original text and is preceded by a historical survey by Ernst Weber, director of the Microwave Research Institute of the Polytechnic Institute of Brooklyn. This introduction comprises a short biography of Heaviside and appreciations of his contributions to vector analysis, electromagnetic field theory, transmission line theory, operational mathematics, loaded communication lines and electromagnetic units, each followed by a list of books and other texts dealing with developments of the respective topics. This survey is well written but is too short to do full justice to the subsequent text, and readers will find it helpful to refer to the much extended appreciation of Heaviside's work contained in the recently published Heaviside Centenary issue of the *Journal of the Institution of Electrical Engineers*, and be able thereby to correct a number of excusable errors in Dr. Weber's biographical statement. The thorough review of Heaviside's work given in this centenary issue makes it unnecessary to comment further on the subject-matter of the book.

WILLIS JACKSON

Measurements of Mind and Matter

By Dr. G. W. Scott Blair. Pp. 116. (London: Dennis Dobson, Ltd., 1950.) 9*s*. 6*d*. net.

THE rheologist's concern is with things like the 'body' of a dough or the 'firmness' of a clay, qualities which defy reduction to simpler physical concepts and which are assessed more consistently by human judgment than by conventional measuring-technique. Materials of this kind can be classified in terms of 'quasi-properties', intermediate between, say, viscosity and elasticity, which appear dimensionally awkward. These represent the response of a material to a changing situation as a whole rather than to a simple change of one or two factors, and Dr. G. W. Scott Blair likens this kind of classification to the methods of Gestalt psychology. He discusses the meaning of measurement in general from the philosophical point of view, and shows the dimensional difficulties that can arise in practice.

The real argument of the book is that in the relatively unexplored field of 'psychophysics', which constitutes the frontier between physics and psychology, a different approach from that of pure physics may be justified; this in itself needs no elaboration, for anything amenable to a purely physical treatment is surely well within the frontier. Nevertheless, a number of controversial points are raised, and the author's own reflexions on them are given in a detached and critical manner. The book is addressed to the non-specialist and the general reader, the latter of whom may find it rather a tough proposition; and its object is rather to give a wider currency to the fact that certain problems exist than to lay down solutions to them.

G. R. NOAKES

Warne's Metric Conversion Tables

Designed by Otto Klein. Computed by Scientific Computing Service, Ltd. Pp. 104. (London and New York: Frederick Warne and Co., Ltd., 1950.) 15*s*. net.

THESE conversion tables have been compiled to meet the demand for a quick and efficient system of converting Imperial and American measures into the metric system, and vice versa. The British and American measures are in the main identical; but confusion is sometimes caused with the Imperial and American gallons, and with the American short and the British long tons. This book certainly covers fairly thoroughly the relations between these, as well as the conversion into metric units. Measures of weight, length, speed, surface, volume and capacity are included, as well as reduction tables, conversion of one temperature scale to another and pressure tables; altogether there are eighty tables.

As regards the use of this book, it will, of course, have a limited appeal in schools and universities, since the conversions are given to a higher degree of accuracy than is ordinarily required (though it might be of some use in schools if it did nothing more than resuscitate the long-forgotten art of 'learning tables'). But its chief use is in the wider field of commerce, and it should be of great value to those engaged in business transactions between countries which have adopted the Imperial measures and those using the metric system.

Natural History

Birds and Mammals. By David Seth-Smith. (Reason Why Series.) Pp. 198. (London: Herbert Jenkins, Ltd., 1949.) 7*s*. 6*d*. net.

DURING his long experience as curator of mammals and birds in the London Zoo and as that popular broadcaster 'The Zoo Man', Mr. David Seth-Smith has had unrivalled opportunities for determining what questions relating to mammals and birds most frequently attract public interest. In this book he has selected and answered 324 of them. The result is a very readable volume, crammed with information, illustrated by sixteen mostly good, full-page line drawings (partly by the author and partly by L. R. Brightwell) and provided with a good index.

The book can be safely placed in the hands of anybody interested in natural history, for the young will find much to stimulate and the old perhaps many things they did not know before. It would have gained had there been a little more critical proof-reading; for example, antlers are nourished by arteries, and not by veins (p. 31); lemmings go right across Eurasia between Scandinavia and North America (p. 51); the cheetah does not owe its speed to semi-retractile claws—actually, the claws are completely retractile although they are not hidden by special lobes of skin when they are retracted (p. 59); and, of the rook, "the food is very varied . . . and probably only becomes harmful to agriculture when too numerous" (p. 159) is not what the author intended to say.

M. A. C. HINTON

ELECTRON-MICROSCOPIC OBSERVATIONS ON THE XYLEM ELEMENTS OF A FOSSIL PLANT

By A. WESLEY and B. KUYPER*
Botany Department, University of Leeds

DURING the course of preparing sections of petrified plant material by the peel-section method of Walton[1], it was suggested by Dr. R. D. Preston that interesting results might be obtained if such plant remains could be examined in the electron microscope. The object of the present contribution is to record the observations so far made by a technique which we believe to be new to palæobotany. Even these preliminary observations have revealed important details which could not easily have been investigated by any other method. The preparation of fossil material for observation in the electron microscope proved to be unexpectedly difficult, but the following method was finally found to be suitable.

A number of peel sections were made from smoothed surfaces of coal-balls to investigate the state of preservation; but in most cases it was found that, for the present purpose, preservation was incomplete or too poor. However, one specimen contained exceptionally well-preserved material, and it was from this block that the preparations and photographs have been made. The specimen is part of a coal-ball, which was presented to the senior author by the late Prof. W. T. Gordon in 1945. Unfortunately the locality from which it was obtained is unknown; but it is undoubtedly of Lower Coal-Measure age. Running longitudinally through the block is a Stigmarian axis and at right angles to this and to one side is part of a decorticated stem of *Lepidodendron vasculare* (Binney) (= *Lepidodendron selaginoides* Sternberg). Only the woody cylinder of the latter is preserved, measuring about 1·5 cm. long and 1·2 cm. in diameter, with the central primary xylem 0·5 cm. in diameter. A surface was ground in a plane tangential to the *Lepidodendron* stele, and preparations were made from the surface of the secondary xylem so exposed.

The new technique involves the preparation of a section of the plant material by the peel-method and then remounting the section on another film for examination in the electron microscope. Only very thin sections of plant material are of any use, and these were obtained by first dissolving out the calcium carbonate from the smoothed surface of the coal-ball by etching with 2 per cent hydrochloric acid for three minutes. This strength of acid and time of etching were found to be most suitable for this particular material, since the coal-ball contains a high percentage of calcium carbonate. A solution of cellulose nitrate in amyl acetate, of the consistency of pure glycerine, was used for obtaining the 'peels'. Each dried film, containing the imbedded plant cell-walls, was then soaked in dilute hydrochloric acid to remove any particles of rock that might have been pulled off when the film was stripped from the block; after washing well in water, the 'peels' were dried under slight pressure to prevent curling.

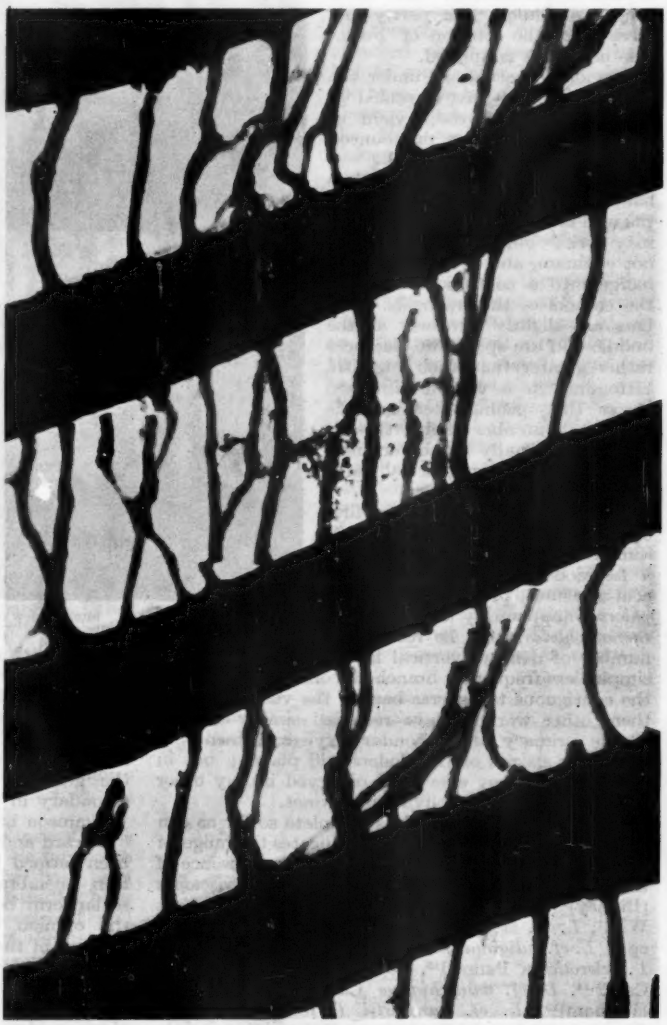

Fig. 1. Portion of a tracheid of *Lepidodendron vasculare* (Binney) showing four transverse scalariform bars and connecting vertical threads (× *c.* 5,450)

* On leave from Messrs. Philips Electrical Co., Eindhoven, Holland.

The surface of the cellulose film which had been in contact with the rock surface was then covered with a thin layer of 'Formvar' dissolved in dioxan (0·25–0·5 per cent), which was allowed to dry. Selected portions of the double-layered film containing the plant material were cut out and placed on the electron microscope grids with the 'Formvar' surface downwards. The cellulose nitrate was dissolved away with amyl acetate, leaving the plant material standing up in relief and attached to the 'Formvar' film. The preparations were then ready for observation in the electron microscope. The use of cellulose nitrate dissolved in amyl acetate is necessitated since other types of cellulose film partly dissolve when the solution of 'Formvar' in dioxan is applied.

Previous observations under the light microscope have revealed in the tracheids of the xylem of Lepidodendroid plants pronounced scalariform sculpturing of the secondary walls with the transverse bars stretching completely across the wall face. Occasionally the bars may fork; but in general this is not common, and in all cases they merge into a continuous layer at the corners of the tracheids. The bars are slightly narrower at the middle and are spaced at distances rather greater than their breadth. Extending in a vertical direction across the openings between the bars are a number of fine threads which occasionally branch or anastomose with one another by transverse connexions.

This peculiar feature was first described and figured by Williamson[2] in "a scalariform vessel from a Lepidodendroid plant from the coal-measures, probably a *Lomatophloros*" (apparently a misprint for *Lomatophloios*), and he records "a number of delicate vertical lines of lignine, usually simple, less frequently branched, connecting together the contiguous transverse bars of the vessel". Since then, other workers have recorded similar threads in the primary and secondary xylem elements of numerous species of Lepidodendroid plants; but in no case have they ever been observed in any other group of plants either living or extinct.

The following list, which is complete so far as can be ascertained from the records, indicates the range of Lepidodendroid species which exhibit the presence of this unusual structure: *Lepidodendron vasculare* (Binney)[3–6], *L. squamosum* (Göpp.)[3], *L. brevifolium* Will.[7], *L. cf. brevifolium* Will.[8,9], *L. brownii* Unger sp.[10], *L. cf. fuliginosum* Will.[11], *L. johnsonii* Arnold[12], *L. scleroticum* Pannell[13], *Lepidophloios wünschianus* Carr.[3,14], *L. cf. wünschianus* Carr.[11], *L. harcourtii* (Witham)[15], *L. cf. harcourtii* (Witham)[7], *Bothrodendron mundum* Williamson sp.[16,17], *Sigillaria boblayi* Brongn.[18], *Stigmaria ficoides* Brongn.[3,6], *Stigmaria* sp.[19], *Lepidostrobus bertrandi* Zalessky[18], *L. brownii* Unger sp.[20].

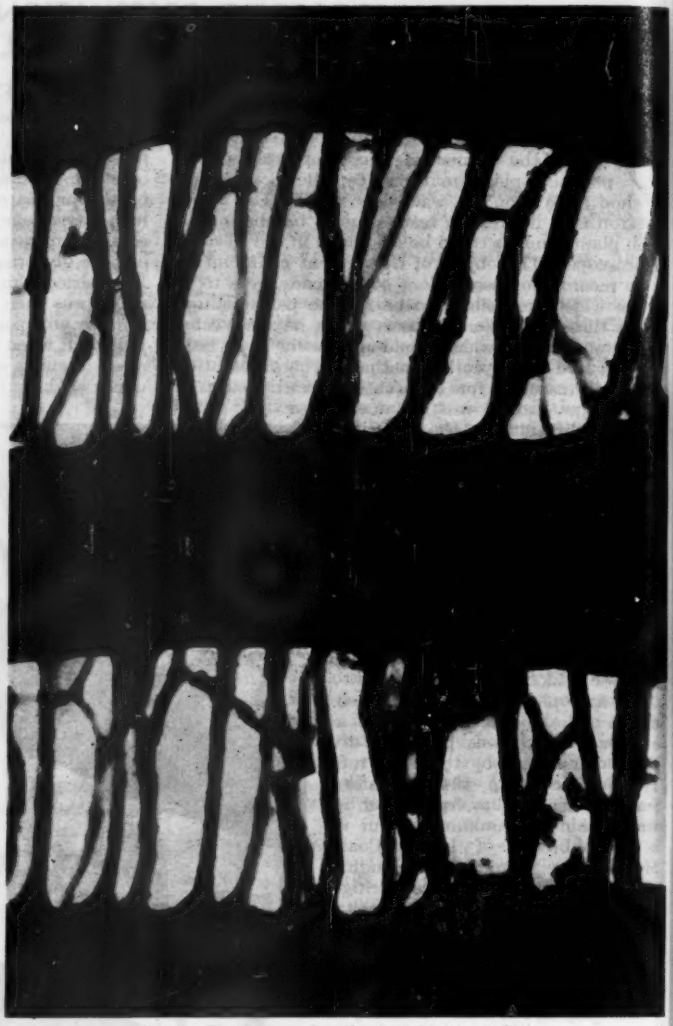

Fig. 2. Similar view of another tracheid (× c. 10,900)

The significance of the series of threads extending across the pit-areas has been discussed by various writers, and divergent conclusions have been reached. It is hoped, in the present contribution, to confirm the generally held opinion that the threads are secondary in nature—the view first put forward by Williamson in 1869 [2].

Seward and Hill[7] suggested that these threads had been formed by the contraction and tearing of the thin membrane which originally connected the scalariform bars. Writing in 1910, Seward[5] added the opinion that the threads probably represent remains of the original wall, which was in process of absorption, but he did not rule out the possibility of post-mortem changes leading to contraction and splitting. On the other hand, Solms-Laubach[3], who also considered the threads to be part of the primary wall, advanced the view that the threads correspond

Fig. 3. Part of the tracheid shown in Fig. 1 more highly magnified. To one side a patch of extraneous matter has become entrapped between the vertical threads (× *c.* 21,800)

to the "*grenzhäutchen*" of the tracheid wall, the middle lamella of which had disappeared. Other writers, including Hovelacque[4], Zalessky[18], Duerden[6], Arnold[12] and Pannell[13], have followed Williamson in regarding them as part of the secondary thickenings which lay against the primary wall and bridged the pit-cavity on the inside of the tracheid wall; but Calder[10], at least for *Lepidodendron brownii* Unger sp., considers them as tertiary thickenings laid down in a thin layer around the bars of the scalariform thickenings, with the fine threads connecting the layers.

Figs. 1–3 illustrate the typical appearance of these fine threads in the electron microscope. So far as can be determined from the preparations that have been examined in the electron microscope, there has been no indication of the presence of the original wall stretching between the threads, or of the middle lamella substance between the xylem elements. The absence of such primary wall structures and the isolation in the coal-ball of the xylem cylinder from any cortical tissues leads to the conclusion that the plant must have died prior to preservation, and that all such delicate structures had decayed and disappeared before petrifaction set in. Only the more resistant plant parts, impregnated with lignin, have actually been preserved. This point alone would suggest that the threads are not part of the primary wall, and reference to the figures will dispel the idea that they represent a stage either in a post-mortem change or in absorption of the original wall, since they are too regular and constant in their breadth. Furthermore, Duerden[6] has figured sections of maturing secondary tracheids where the threads are being formed against the inside of the primary wall.

The possibility of their being tertiary in nature still remains, and on consideration it may seem that the threads might not be, in fact, attached to the transverse bars, but to some other layer enclosing the bars. We have, however, never observed such a layer surrounding the bars as was envisaged by Calder, and our preparations have shown that, where the threads have been slightly damaged or completely removed, they leave distinct pegs firmly attached to the bars (Fig. 1).

It seems certain, therefore, that the transverse bars and vertical system of threads are part of one and the same wall structure, and the evidence obtained from our new observations, together with those of certain previous workers, indicates that the series of threads form part of the secondary wall deposits.

In some places (Figs. 1–3), running in a different but parallel plane, two systems of threads are evident which belong to the two neighbouring walls of adjacent tracheids. Examination of the electron micrographs reveals an additional point of interest. The two systems of threads which cross the pit-areas between the transverse bars of adjacent tracheids

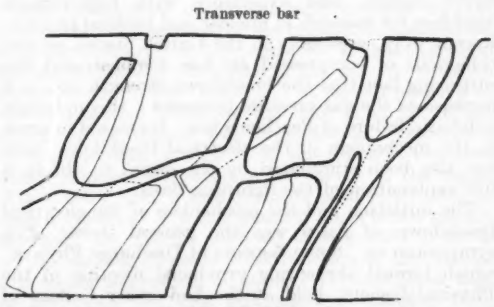

Fig. 4. Diagrammatic representation showing arrangement of two sets of threads on adjacent wall faces. The nearer transverse bars and series of vertical threads are outlined more heavily than the corresponding structures of the adjacent tracheid

bear no relation to one another, either in their pattern of branching or at their points of attachment to the transverse bars. The smaller pit-areas which are thus formed between the individual threads do not entirely correspond with a similar region on the wall of an adjacent tracheid and are virtually blind in some parts (Fig. 3). Fig. 4, which has been redrawn from Figs. 1 and 3, shows this point particularly well.

The possibility that any two adjacent series of threads may have become slightly distorted or moved out of alignment with one another during fossilization or preparation of the cellulose nitrate 'peels' is precluded by the very little lateral movement which occurs when fractures break some of the threads. In addition, a number of tracings was made, but in no case was it possible to 'fit' the pattern of any set of threads with the corresponding series of an adjacent tracheid wall.

We are indebted to Dr. R. D. Preston for permission to use the electron microscope provided by the Department of Scientific and Industrial Research, and gratefully acknowledge his advice and help during the course of this investigation.

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PHYSICS OF ELECTRICAL DISCHARGE

DURING recent years the mechanism of the electrical breakdown of gases has been a subject of renewed interest. This is due to a variety of causes—in particular, the increasing use of compressed gases as a dielectric with high voltages (as in power cables), and experience with high-voltage machines for research in nuclear and medical physics. Recent work, especially in the United States, on the behaviour of compressed air has demonstrated the surprising fact that the breakdown strength does not increase as the gas pressure increases; this indicates a definite failure of Paschen's law. Increased interest in the mechanism of the electrical breakdown itself has also been stimulated by the desire to obtain a full explanation of the lightning flash.

The initiation and the mechanism of the electrical breakdown of gases was the general theme of a symposium on "Some Aspects of Discharge Physics" which formed the spring provincial meeting of the Physical Society, held at the University College of Swansea during March 29–31. The hundred and fifty scientific workers present, though mainly physicists, included a number of electrical engineers and mathematicians; and a large number of universities, government research establishments, industrial research associations, electrical and other industrial firms were represented at the meeting. The president of the Physical Society, Prof. L. F. Bates, in welcoming the members, pointed out that this was the first visit of the Society to Wales. On the afternoon of March 29 visits were made to the Abbey works of the Steel Company of Wales, and to the Gower Peninsula. On the morning of March 31 a tour of the Department of Physics of the University College of Swansea was made, and of the Sketty Hall Laboratories of the British Iron and Steel Research Association. Altogether, the success of the meeting showed the great interest now felt in discharge physics.

The symposium started with an address by Dr. A. H. von Engel (Oxford) on recent advances in the subject of fundamental collision processes. Examples of ionization by electrons and photons with energies less than the ionization energy were given; mercury vapour can be ionized by low-energy quanta producing two excited atoms which collide to form a molecular positive ion and a free electron. Again, auto ionization is an important cumulative process, for example, in metal vapours: first, two electrons are excited in the same atom, and one of them may then be released if the total potential energy of the atom exceeds the ionization potential. Further, two normal identical atoms may become ionized by collision if their relative velocity exceeds a critical value which corresponds to twice the ionization energy; this has been shown experimentally, and it agrees with classical laws of transfer of energy in collisions. Recent work on ion mobilities was then discussed: the disagreement between theoretical and experimental values of the mobility of positive ions of rare gases moving in their own gas has been found to be due to the formation of molecular ions (for example, He_2^+), which, unlike atomic ions, do not transfer their charges in collisions to neutral atoms. After discussing dissociative recombination, Dr. von Engel concluded by stressing that discharge physics is now entering a most interesting phase.

The next paper, given by Prof. Llewellyn Jones, was on the electrical breakdown of gases. From experimental investigations during the past twenty years, it had widely been concluded that the growth of pre-breakdown currents at high pressures followed a simple exponential law (involving no secondary ionization), and that to account for sparking it was therefore necessary to assume the sudden introduction of an entirely new ionization mechanism (streamer) not related to the growth of initial pre-breakdown currents[1]. This assumption was critically analysed by Prof. Jones, who showed that the experimental data were insufficient to justify such an assumption. The difficult experimental conditions which must be satisfied in order to investigate the problem over the significant range of spark parameters were discussed, and a high-voltage ionization chamber which has been designed and built to satisfy these conditions was described. With this apparatus, measurements have been made at Swansea of pre-breakdown ionization currents for values of the spark parameter ap, which included those corresponding to a 1-cm. gap in the atmosphere[2]. The results show that, while the growth of the currents is simply exponential over the greater part of the sparking distance, in the important region near breakdown itself the currents do, in fact, increase at the faster rate represented by

an equation of the Townsend type involving primary and secondary ionization coefficients α and ω. This indicates that the mechanism of the spark itself is the same as that which leads to the growth of the photo-current even in its early stages ($i \sim 10^{-15}$ amp.). Possible secondary ionization processes were discussed in the paper—such as the ionization of gas atoms by photons, or by collision through the agency of positive ions involving electron transfer and the production of fast neutral atoms[3]; and also the cathode processes of secondary emission by positive ions or by photons. It was stressed that the essential feature of the breakdown mechanism is the development of the avalanche from behind by a secondary generating cause moving towards the cathode, a process which is most efficient when it acts at the cathode itself. Evidence was also given for the existence of secondary emission from the cathode by the impact of positive ions even with spark voltages up to 30 kV. W. Hopwood (Liverpool) then followed with a paper on the positive streamer mechanism. He pointed out that, in view of the experimental results of Llewellyn Jones and Parker[2] and recent work in the United States[4] on the formative time-lag of sparking in the important region near breakdown, some modification of the original streamer type theory is now required.

There was active discussion of these papers. C. G. Morgan (Swansea) dealt with the failure of Paschen's law at high voltage[5], and indicated that the intervention of cold-cathode field-emission is sufficient to explain this failure and also some experimental results of his own. R. Fortescue (Queen Mary College, London) raised questions on the interpretation of photographs of anode and mid gap streamers, on instability at breakdown and on the physical explanation of the influence of the cathode on breakdown at very high pressures. E. H. Cohen described recent high-voltage work done at Queen Mary College employing gas pressures of 1,000 lb./sq. in. S. Haydon (Swansea) gave theoretical considerations of photo-ionization in the gas; preliminary calculations with Dr. P. M. Davidson suggest that such processes do not predominate in the spark mechanism in air at high pressure; but for detailed calculations further numerical data on absorption cross-sections are required. J. Dutton (Swansea) discussed the interpretation of the results of recent work on formative time-lags[4], and showed that these are fully consistent with modern work on the growth of pre-breakdown currents, described above, and with the explanations proposed, concluding that a streamer mechanism is both insufficient and unnecessary to explain these results.

The session on March 30 opened with a paper by C. G. Morgan (Swansea) on the cold emission of electrons and discharge initiation. Cold emission from various electrode surfaces in air at atmospheric pressure under fields of the order of 10^5 volts/cm. has been found to depend strongly upon the nature of the electrode surfaces: thin oxide films or microscopic insulating particles give rise to enhanced electron emission[6]. Experiments have shown that the emission follows a field law. The role of post-breakdown residual positive ions in initiating succeeding sparks has also been examined, and it is concluded that a surface charge of positive ions on an insulating film at the cathode can give rise to enhanced field emission. This effect can lead to failure of Paschen's law. R. D. Craig (Metropolitan-Vickers Electrical Co., Ltd.) described experiments on the production of electrode vapour and its effects on the afterglow: 10 μsec. high-current pulse discharges were employed with electrodes of magnesium, copper, iron, carbon and tungsten. The observed large transport velocity of electrode material can only be explained if it leaves the electrode in the form of droplets or liquid jets.

In the discussion which followed, J. C. S. Shaw (Cambridge) pointed out that Mr. Morgan's views are consistent with present knowledge of backfires in rectifiers[7]. W. D. Chesterman (Admiralty Research Laboratory) described some of his experiments on the production of light flashes by the discharge of a condenser through a sealed quartz tube. G. G. Isaacs (G.E.C. Research Laboratory, Wembley) outlined work on high-pressure mercury vapour discharges, and showed that the cathode may give rise to effects extending far beyond what is usually regarded as the cathode region at these high pressures.

In the afternoon of March 30 there were four papers on high-frequency discharges. Dr. G. D. Morgan (University College of North Wales, Bangor) discussed breakdown and described experiments at Swansea made in hydrogen at low pressures p and at frequencies f between 5·0 and 70 Mc./s. to test the validity of a general similarity theorem: $V_s = \varphi(ap, f/p)$. The theorem holds accurately for breakdown, but less accurately for maintained high-frequency currents—this he attributed to discharge instability. G. Francis (Oxford) has found that the growth of electrodeless discharge at low pressure proceeds in three stages: the first stage is a multiplication of electrons by secondary emission from the glass walls of the vessel; the second is the production of a distributed positive space-charge of gas ions with a maximum at the centre of the vessel; finally, an equilibrium state is established when the production of ions and electrons in the gas equals the losses to the walls. A new technique has been used, and oscillograms showed how the growth of the discharge depends on the pressure and on the gas. W. L. Harries (Oxford) described the mechanism of the low-frequency electrodeless discharge in chlorine, and the influence of irradiation. He has found that the current consists of pulses, the number increasing with the voltage: each pulse corresponds to a series of electron avalanches developing between small areas of the inner glass surfaces. G. C. Williams (Swansea) described his work on the similarity theorem and corona relationship for both static and high-frequency discharges in air, hydrogen and monatomic gases; he also discussed the mechanism of the static corona discharge.

The symposium concluded with a paper by Dr. Elwyn Davies (Swansea) on the breakdown mechanism in static discharges at low pressures. He has examined the dependence of the shape of the cathode emission (ω/α) curves on the deposition of electro-positive or electro-negative atoms on cathodes of nickel, aluminium, silver, copper and molybdenum. Deposition of electro-positive atoms on the cathode produces sharp photoelectric peaks in the curves in the region $X/p \simeq 150$ V./cm. × mm. pressure of mercury; but at higher values of X/p the quantity (ω/α) is not greatly affected. Dr. Davies analysed these results in terms of the varying effective work function of the surface due to the deposition of atoms. He concluded that in hydrogen the high photoelectric emission from cathodes of low effective work function is due to low-energy photons generated in the pre-breakdown currents, but that for clean metals the secondary

emission is due almost entirely to the impact of positive ions; photoelectric emission due to any high-energy photons generated in the ionization currents is negligible in comparison. Thus the breakdown process is almost completely determined by the nature of the cathode surface. The succeeding discussion included contributions from Prof. J. M. Meek (Liverpool) and J. R. Acton (Ericsson Telephones, Ltd.).

F. Llewellyn Jones

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REPORT OF THE COMMITTEE ON WEIGHTS AND MEASURES LEGISLATION

SOME important recommendations, of widespread interest, emerge from the deliberations of the committee appointed by the President of the Board of Trade to review the existing weights and measures legislation and administration in Great Britain. The report* presents the results of the first full inquiry into this subject since that of the Standards Commission of 1867–70. Not unnaturally, in view of the large amount of legislation which has since been effected, the recent committee, under the chairmanship of Sir Edward Hodgson, advocates a consolidation of the law in regard to weights and measures; but the chief scientific interest lies in Part 1 of the report, dealing with the units and standards of measurement. Foremost among the items of Part 1 is the recommendation that the Imperial system of units should eventually be abolished in favour of the metric system. This recommendation is unanimous and, as the committee says, contentious in the extreme. It visualizes a lengthy period to prepare the general public for the change and to provide schemes for the change-over, trade by trade, during a transition period extending over twenty years or more. But, above all, the recommendation is conditional on an approach being made to the Commonwealth and the United States, so that all may move together, or not at all.

When the Commission of 1867–70 examined this question, it recommended that the use of the metric system concurrently with the Imperial should be permitted for the purpose of trade. As a result of this recommendation, provision was made for the use of approved metric standards of weight and measure. In 1870 the metric system was compulsory in fifteen countries, but when the Hodgson Committee approached the matter, the number of such countries in the world had increased to fifty-five, the outstanding exceptions being the Commonwealth and the United States, which together conduct half, if not more, of the world's trade, using chiefly the yard–pound system. In the face of conflicting external factors and the mixed evidence submitted, the Committee found no easy solution. The real problem before it was whether to maintain two legal systems or to take steps to establish world-wide uniformity by changing completely to the metric system. The Committee, while bearing in mind the well-known objections to the change and in particular the difficulty of altering the units of measurement in the engineering and other industries, has resisted the arguments in favour of retaining the present concurrent use of both systems and has laid more stress on the part to be played by Great Britain in the international affairs of the future, in trade and commerce, defence, etc. The future needs of the country are not easily assessed, but at no time have smooth international dealings been so important as at present.

Much has been said on the subject by pro- and anti-metricists, as for example at the discussion at the British Association meeting in Brighton in 1948. It is hoped that any differences of opinion as to the Committee's recommendation will rise above the usual retorts as to the relative shortcomings of this or that set of units and reach a level where the significant factors are disentangled from the irrelevant. Looking back over a hundred and fifty years since the initiation of the metric system, we cannot close our eyes to its advance; and there is no indication that the trend towards its universal adoption has been reversed. It remains to be seen whether the Committee's long-term view on this subject will eventually receive sufficient support to overcome the inherent objections to the change.

The Committee, in making this recommendation, also envisaged the decimalization of the coinage, but this matter was considered to be outside its terms of reference. As a shorter-term proposal of the wider project, the Committee recommends that the apothecaries, troy and pennyweight systems of measurement should be abolished after five years and replaced by the metric system. This, though it might be regarded as a 'thin end of the wedge' for the long-term project, has the obvious advantage of removing from the Imperial system much unnecessary complexity of units; moreover, metric weights are normally used in scientific work.

Whether the long-term proposal to change to the metric system is accepted or not, strong support should be forthcoming for the recommendation that the independence of the Imperial and metric units of length and mass should be terminated, and that the yard and pound should be defined in law as definite fractions of the international metre and kilogram respectively. This proposal was put forward in 1946 by the British Empire Scientific Conference and has two main objects. The first is to remove embarrassments arising from the existing situation and particularly those caused by variations from time to time in the relationship of the material standards of the yard and the metre to one another, and also those of the pound and kilogram. The effect of the slight progressive shortening of the Imperial Standard Yard is sufficient to be felt in high precision measurements with engineering standards and in the surveying field. The second object is to eliminate the small differences which exist between the Commonwealth and the American yards and pounds. The differences have arisen because these units have been defined in Britain by reference to independent standards, whereas in the United States, ever since 1866, they have been defined by fixed ratios to the metre and

* Board of Trade. Report of the Committee on Weights and Measures Legislation. (Cmd. 8219.) Pp. iv+147. (London: H.M. Stationery Office, 1951.) 3s. 6d. net.

kilogram respectively. The Committee recommends the general adoption of the principle of fixing the yard/metre and pound/kilogram ratios, and proposes to apply it in a most rational manner to bring the Commonwealth and American yards and pounds into equality. The definitive values recommended are as follows: 1 yard = 0·9144 metre (corresponding to 1 inch = 2·54 centimetres exactly); 1 pound = 0·453 592 37 kilogram or 0·453 592 3 kilogram.

With the view of their adoption in the Commonwealth and the United States, the Committee suggests that the Government of the United States be informed of these proposals. This is a worthy project which should be strongly pursued between the countries concerned. Scientific workers generally, and metrologists in particular, will support the proposal.

In connexion with the legal definitions of units and standards of measurement used in Great Britain, it has been found that these are not always satisfactorily prescribed in an Act of Parliament. An element of flexibility is essential to enable British practice to keep abreast of the latest technical developments and international agreements, and for various purposes the Committee recommends suitable machinery for effecting changes whenever the need arises. This machinery is based on the principle of delegated powers of legislation to be exercised by the Minister within the broad purposes of an Act. In order to provide satisfactorily for definitions in law of certain units, for example, those of time, capacity, temperature, heat and electricity, together with the prescription of standards for such units, and associated matters, it is proposed that a permanent commission be appointed by the President of the Board of Trade to advise on such subjects. The Committee has in mind a strong and wide advisory basis for this work and suggests that the commission should consist of the Astronomer Royal, the director of the National Physical Laboratory, the president of the Royal Society, two members nominated by the Lord President of the Council, one by the Lord Chancellor, and the chairman and not more than three other members by the President of the Board of Trade. It is recommended that the President of the Board of Trade be empowered to give effect by subordinate legislation to the recommendations of the commission and required to lay before Parliament at appropriate intervals a report on its work.

Concerning the more general conclusions to which the inquiry has led, the Hodgson Committee is satisfied that the existing principles of weights and measures law are soundly based and stand in no need of fundamental revision. They have provided a reasonable protection to all engaged in trade, and the machinery of administration appears to have worked well over the years. In the remaining parts of the report, recommendations of varying scope and importance are made in regard to weighing and measuring equipment and the protection of the public against the giving of short weight or measure; but, in the main, these proposals represent additions to, or simplifications of, the present framework, rather than completely novel features. It is recommended that the administration of weights and measures law should continue to be in the hands of local authorities, but should be entrusted in future only to those larger authorities the work of which would require the employment of at least three inspectors. On this basis there would be eventually about a hundred and forty weights and measures administrative units in place of the 258 at present, and more economical use of staff could justifiably be expected from such a change. As in the past, the Board of Trade through its Standards Department should bear the ultimate responsibility for ensuring efficiency. The main duties of the Department are defined, with a recommendation that its name be changed so as to avoid confusion with the British Standards Institution, which, as is well known, deals with standards from another aspect.

It is hoped that, whenever there is general agreement that the Committee's recommendations are wise and can be implemented without much upheaval, they will be put into effect with reasonable promptitude. In particular, the redefinition of the yard and pound in terms of the metre and the kilogram is a reform long overdue, which should not be delayed on account of other recommendations which may appear controversial or involve major difficulties.

F. A. Gould

OBITUARIES

Prof. Alexander McKenzie, F.R.S.

With the death of Prof. Alexander McKenzie, emeritus professor of chemistry in the University of St. Andrews (University College, Dundee), on June 11, at the age of eighty-one, another link has been severed with the great classical age of organic chemistry.

McKenzie was the son of a village schoolmaster in Angus and received his early education at the High School, Dundee. He entered the United College, St. Andrews, in 1885 and laid a sure foundation for his liberal outlook of later life by reading for the M.A. degree before embarking upon his studies in chemistry. The thrill of research soon captivated him, and after working under Thomas Purdie for a while he gave up, at considerable personal sacrifice, his lectureship at the United College to work with Marckwald in Berlin. His Ph.D. thesis there was a masterpiece which has become a classic. Shortly afterwards he graduated D.Sc. of St. Andrews and embarked on his teaching career, first in London and then in Birmingham, where he became special lecturer in organic chemistry. In 1905 he was appointed head of the Chemistry Department in Birkbeck College, London, a post which he held with such distinction that he was the obvious choice for the chair in his native Dundee when this fell vacant at the end of 1913.

During 1914–38 McKenzie was professor of chemistry in University College, Dundee. His researches expanded and developed throughout the field of stereochemistry, and his reputation became world-wide. At home the merit of his work was recognized by his election in 1916 as a Fellow of the Royal Society, and in Germany by the rare distinction of his admission as an Honorary Fellow of the Kaiserlich Deutsche Akademie der Naturforscher, Halle. On his retirement he received the LL.D. of St. Andrews.

McKenzie's research work was mainly concerned with stereochemical problems, in particular as applied to the derivatives of mandelic, tartaric, malic, maleic and fumaric acids. The isolation of the optically active forms of benzoin and his work on catalytic racemization are examples of his early pioneering. A clear appreciation of the factors leading to loss of optical activity enabled him to devise and carry out the first asymmetric synthesis of mandelic acid; and this was followed by further successful syntheses of

the same kind. McKenzie will also be remembered for his work on the Walden inversion, which also led to the investigation by polarimetric methods of the deamination reactions of α-amino-alcohols and the accompanying migration of organic radicals. These topics provided material for a long series of important researches. All his work was characterized by a subtle elegance which led one of his colleagues to comment that "in attacking the refined secrets of the organic molecule he discarded the ponderous weapons of men of grosser mould for the light rapier of the 'chymicall Artist' ".

McKenzie also possessed an acute faculty for the appraisal of work besides his own, as witnessed by his early applications of the Grignard reaction. Furthermore, he had the philosophical and cultural outlook characteristic of the scientific men of his generation, an outlook which is so often lacking to-day.

He was an inspiring teacher, and during his twenty-five years in Dundee he trained a steady stream of research students. He took a lively and enduring interest in the personalities and progress of his pupils, an interest which he maintained throughout his years of retirement. His enthusiasm for the progress of organic chemistry never flagged, and he insisted on reading every new thesis on organic chemical topics originating from the Department.

He is survived by Mrs. McKenzie and their son.

D. H. Everett

We regret to announce the following deaths:

Sir Walter Johnson, C.M.G., director of medical and sanitary services in Nigeria during 1929–36, known for his work on trypanosomiasis and yellow fever, aged sixty-five.

Commissioner David Lamb, C.M.G., LL.D., director of the Salvation Army Emigration Department during 1903–30 and known for his social studies, who frequently attended meetings of the British Association, on July 7, aged eighty-four.

Mr. William Lowson, formerly senior lecturer in analytical chemistry in the University of Leeds, with which he had been associated since 1897, on May 20.

Prof. H. Nagaoka, professor of physics in the University of Tokyo during 1896–1926, on December 10, 1950, aged eighty-five.

Dr. John Rickman, sometime president of the British Psychological Society and for many years editor of the Society's *Journal*, aged sixty.

NEWS and VIEWS

Institute of Navigation: Thurlow Award

Dr. E. G. Bowen, chief of the Division of Radiophysics of the Commonwealth Scientific and Industrial Research Organization, Sydney, has been given the Thurlow Award for 1950 of the Institute of Navigation, of the United States, for his outstanding contribution to scientific navigation during the past year. The Award is a memorial to Colonel Thompson L. Thurlow, formerly chief of the Navigation and Instrument Section of the Equipment Laboratories of the United States Air Force at Wright Field, Dayton, Ohio, who was killed in 1944. Dr. Bowen and his co-workers have developed several new radio navigational aids which are of special importance in aviation. Their distance-measuring equipment (D.M.E.) has been adopted for civil airline use in Australia. For the first time it provides the pilot of an aircraft with an instrument showing his distance from an airport he is approaching. Another system they have developed, multiple-track radar range (M.T.R.), enables aircraft to fly on a series of tracks radiating from an airport. It has aroused considerable interest in aviation circles overseas. Their latest device is a microwave navigational system which provides a radio counterpart to the simple visual method of navigation using beacon lights. It enables the pilot to 'see' and use radio beacons in thick weather in as nearly as possible the same way that ground markers or light signals can be used as navigational aids under conditions of perfect visibility. It offers great promise as a navigational system for use by aircraft where it is uneconomical to provide the elaborate facilities used on main air routes, and for use by ships in confined waters.

Dr. W. J. V. Osterhout

Dr. W. J. V. Osterhout, the well-known American botanist, will celebrate his eightieth birthday on August 2. Dr. Osterhout has, since the beginning of the century, established himself as one of the world's authorities in plant physiology, especially cell physiology, working mainly in the University of California and Harvard University until 1925, when he transferred to the Rockefeller Institute, New York. From there he retired when he reached his seventieth year; a note of appreciation was published in *Nature* at that time (**147**, Jan. 25, 1941). Dr. Osterhout has trained or inspired workers in the subjects of his choosing in all parts of the world. We should like to join all those in congratulating him on this occasion and to express the hope that he will long continue to exert his powerful influence and encouragement.

Royal Society Research Fellowships

Dr. C. E. Lumsden, of the University of Aberdeen, has been appointed second Henry Head Research Fellow of the Royal Society from October 1, to work at the Maida Vale Hospital for Nervous Diseases and the National Hospital for Nervous Diseases on disseminated sclerosis. The Council of the Royal Society has appointed Dr. D. R. Wilkie to be the first Locke Research Fellow, from October 1, to work at University College, London, on energy relations in muscular contraction. Frank Spiller Locke, formerly reader in physiology at King's College, London, who died in 1949, left part of his estate to the Royal Society for the endowment of Locke research fellowships in experimental physiology and pharmacology. The Council has also appointed for the first time two Stothert Research Fellows, each for two years in the first instance, from October 1. Mr. J. R. Vane will work at the Nuffield Institute for Medical Research, Oxford, on the mechanism by which histamine produces gastric secretion, and Mr. J. M. Walshe will work at University College Hospital, London, on amino-acid metabolism in liver disease. The Stothert Research Fellowships are established by the bequest to the Royal Society of the residuary estate of Dr. John Henry Stothert, lecturer in pharmacology at University College

Hospital, who was drowned at the age of twenty-seven in a canoeing accident in Austria in 1937; the bequest came to the Society in 1948 after the death of Lady Stothert.

Agricultural Machinery at the Science Museum

THE collections of agricultural implements and machinery at the Science Museum, started in 1857, contain a fine historical series from which a selection has been made for public exhibition. They were taken to the country for safety in 1939 and it is only now possible to show them again to the public. The present display occupies the first floor of a building block of which the frame, with temporary wall panels, was constructed before the War as a part of the original East Block, but not completed and furnished until now. In this, the first section of the newly finished museum building to be opened, daylight has been excluded and by use of controlled fluorescent lighting it has been possible to incorporate several novel methods of display. These, while avoiding the transience of the display methods now common in trade exhibitions and the like, have nevertheless been devised with the view of the maximum visual appeal. Recent developments have been shown by means of a series of nearly a hundred models, all to a scale of one inch to a foot, contributed by some twenty firms in the industry. These are displayed against scenic backgrounds with plaster bases and illustrate the work of the up-to-date mechanized farm throughout the seasons of the year. As a centre-piece there is a full-sized sectioned and working combine harvester. Other full-size exhibits include early ploughs, a horse wheel, Bell's reaper of 1826 and the Ivel farm tractor of 1902, the first medium-powered farm tractor driven by an internal combustion engine. In the space at present available it has only been possible to deal with arable farming. The display has been planned in close consultation with the Ministry of Works, which has been responsible for the design and provision of the building, lighting, display cases, etc.

Gas Council Research Centre at Birmingham

THE Gas Council has set up a second research centre at the Nechells Gasworks, Birmingham, the work of which will be mainly concerned with the complete gasification of coal. This centre will be administered by the West Midlands Gas Board on behalf of the Gas Council, and its director will be Dr. F. J. Dent, at present assistant director of the Gas Research Board. Dr. Dent has been closely concerned with the experiments upon complete gasification which have been conducted at the Poole Research Station. Great importance is attached to this particular field, and the Gas Council has decided that this work can be accelerated at Birmingham where there are far greater facilities than at Poole, although this does not mean that the work at Poole will cease.

Expedition to Chubb Crater in Northern Canada

THE National Geographic Society and the Royal Ontario Museum, Toronto, are sending a joint expedition to far northern Canada to explore the recently discovered Chubb crater. Dr. Victor Ben Meen, a well-known Canadian geologist and director of the Museum, will lead the expedition. The crater site is in northern Quebec between Hudson Bay and Ungava Bay, and the expedition, which is travelling by air, expects to land on a near-by ice-free lake and make camp as near the boulder-strewn crater as is possible. The crater is more than two miles wide and hundreds of feet deep, surrounded by a rim averaging 400 ft. high. Dr. Meen saw the crater last year when he surveyed the area in the company of Frederick W. Chubb, a prospector who discovered it, and after whom it is named. Its appearance suggested a tilted cup with one side considerably higher than the other. It is thought that the crater may have been caused by the fall of a meteorite. The expedition is taking modern scientific equipment and will attempt to ascertain the origin of the crater.

Courses and Examinations for Instrument Maintenance Mechanics

THE City and Guilds of London Institute has recently announced the adoption of a new scheme of courses and examinations in instrument maintenance (Subject No. 79). The scheme, which has been drawn up by an advisory committee representing a wide range of interested bodies, is intended for mechanics and technicians concerned in the maintenance, repair and installation of the instruments used for process and production control in industrial plants and in the Armed Services. Particular attention has been given to the requirements of the chemical, iron and steel, and petroleum industries, to fuel economy, and the needs of the Services; but the structure of the scheme is such that it will have wide application. The courses consist of five years of part-time study at a technical college, with an intermediate examination at the end of the third year, and a final examination at the end of the fifth year. There is provision for students holding an appropriate Ordinary National Certificate to enter the course at the beginning of the fourth year. It is hoped that by the provision of these courses the serious shortage of skilled instrument mechanics which is at present handicapping British industry will be effectively reduced. Further details of the scheme, including a pamphlet containing the regulations and syllabuses for the City and Guilds examinations (available shortly, price 6*d*.) can be obtained from the Department of Technology, City and Guilds of London Institute, 31 Brechin Place, London, S.W.7.

A Pioneer in Modern Farm Practice

A RECENT number of the magazine *Scotland* (No. 52, June 1951) includes an article extolling the important contributions made by scientific men from Scotland, and in particular from Glasgow, to the development of the industrial revolution and of the atomic age. While these are, for the most part, well known, the author, Prof. Hugh Nicol, of the West of Scotland Agricultural College, also places on record the interesting fact that at the commencement of the nineteenth century a Glasgow citizen, William Harley, author of "The Harleian Dairy System" (1829), ran an internationally famous dairy farm in Glasgow. In the dairy, which held two hundred cows, of which a careful register was kept, there was a steam engine which operated machines for turnip-slicing, chaff-cutting and churning. This machine was in operation in 1814 and possibly as early as 1812, in the same year, as Prof. Nicol puts it, that the famous steamship the *Comet* first sailed on the Clyde; it is claimed to be the earliest known instance of the use of steam for agricultural purposes.

Representation of Snow in Museum Displays

THE standards of modern display make great demands on the museum curator, who is constantly

called upon to reproduce natural environments of various types. Perhaps a snow scene is one of the most difficult to construct, and its realism is often marred, not least by streaks of dust. In the December 1950 issue of the *Museums Journal*, W. T. Stirling, of the Royal Scottish Museum, Edinburgh, describes, with operational details, a method by which 'snow' is made from paraffin wax. Molten wax is sprayed with considerable force on to the surface of cold water contained in a large sink, and from a distance which confines the wax particles to the water surface. The accumulating solidified particles are periodically removed and placed in a fine-meshed sieve to drain. Finally they are heaped on to the exhibit. This method obviates any surplus wax on the specimens or the case, and has the advantage that the 'snow' may be arranged in any way, and may be re-arranged if soiled by dirt. The characteristic sparkle may be obtained by liberally sprinkling with thinly blown and finely fractured glass.

Heriot-Watt College, Edinburgh: Award of Fellowships

The governors of the Heriot-Watt College, Edinburgh, have instituted a new award, namely, fellowship of the College, designed primarily to encourage original work in those branches of study at present recognized for the associateship of the College, namely, mechanical and electrical engineering, applied chemistry, mining engineering, brewing and fermentation industries. The fellowship is open to (*a*) an associate of the College of not less than five years standing, who presents a thesis embodying the results of original research carried out since leaving the College; (*b*) associates or others holding equivalent qualifications, who complete a period of advanced study in the College and present a thesis. The governors of the College also have powers to confer the honorary fellowship on persons distinguished in science or engineering connected with the College. It is hoped that the institution of this award will in due course give an impetus to the extension of the research activities and higher technological training in the College, and so enable it to play an ever-increasing part in developing industrial productivity.

On July 10, the Lord Provost of the City of Edinburgh, the Right Hon. James Miller, conferred the honorary fellowship of the College on the following old students, former members of staff and governors of the College: John M. Caldwell, general manager, Scottish Oils, Ltd.; Prof. Raymond G. H. Clements, emeritus professor of highway engineering, Imperial College, University of London; Major-General David R. Duguid; Dr. Charles Forrester, deputy chief fuel engineer, Ministry of Fuel and Power; Prof. James Greig, William Siemen's professor of electrical engineering, King's College, University of London; Wm. Hamilton Gray, senior partner with the firm of McKerrell Brown & Gray; Prof. Alex. R. Horne, emeritus professor of mechanical engineering, Heriot-Watt College; Dr. Edward Hughes, vice-principal, Brighton Technical College; J. Morison Inches, managing director of J. & J. Morison, Ltd.; Peter Kerr, technical secretary of the Institute of Petroleum; Henry R. King, production director, Scottish Division, National Coal Board; James M. Mackintosh, formerly organizer of further education under Edinburgh Corporation Committee; Dr. Wm. Maxwell, until 1949 managing director of Messrs. R. & R. Clark, Ltd.; Dr. Christina C. Miller, lecturer in chemistry, University of Edinburgh; Dr. David Penman, formerly principal, Indian School of Mines; Dr. John S. Penman, vice-principal, Barnsley Technical College; Dr. Willison B. Peutherer, manager, Grangemouth Refinery, Scottish Oils, Ltd.; Dr. James Sandilands, assistant professor, Heriot-Watt College; Roderick M. Shearer, formerly head of the Mathematics Department, Heriot-Watt College; Dr. James Cameron Smail, emeritus principal, Heriot-Watt College; Dr. Alex. M. Smith, head of the Department of Chemistry, College of Agriculture, Edinburgh; Dr. John B. Tait, senior principal scientific officer, Marine Laboratory, Scottish Home Department, Aberdeen; Dr. J. Albert Thomson, chairman and managing director, Brown Bros., Ltd., London; Wm. Watson, formerly head of the Physics Department, Heriot-Watt College; Robert Wilson, director, Pillans & Wilson, Ltd.

National Radio Exhibition

The term 'Radiolympia' has in the past become well known to all those who are interested in the exhibition organized and held in London under the auspices of the Radio Industry Council. This year, circumstances have necessitated a change of name to that of National Radio Show, and it will be held at Earls Court during August 29–September 8. In connexion with this exhibition, a very interesting and well-produced booklet has recently been issued by the above Council. It is entitled "British Radio and Television for the World—London 1951"; and is intended to interest the overseas reader who will be visiting Great Britain in connexion with one or other of the several exhibitions being held in the early autumn of this Festival of Britain year. The contents of the booklet deal with the current state and trends of technical development in the fields of television, radio and sound reproduction, communications and navigational aids, electronics, including equipment for industrial, medical and scientific purposes, and with valves, cathode ray tubes, components and accessories. All these subjects are illustrated by many interesting photographs, including views of the Birmingham television installation and an associated relay station, the sound-reproducing arrangements in the new House of Commons and, literally, a thimbleful of sub-miniature valves. Copies of the booklet are obtainable on application to the Secretary, Radio Industry Council, 59 Russell Square, London, W.C.1.

Royal Meteorological Society: Officers

The following have been elected officers of the Royal Meteorological Society for the year 1951–52: *President*, Sir Charles Normand; *Vice-Presidents*, Wing-Commdr. Poulter, Dr. R. C. Sutcliffe, Sir Robert Watson-Watt, W. M. Witchell; *Vice-President for Canada*, A. Thomson; *Vice-President for Scotland*, Sir Ernest Wedderburn; *Secretaries*, Prof. P. A. Sheppard, R. G. Veryard; *Treasurer*, Prof. G. C. McVittie; *Editor*, Prof. P. A. Sheppard. The new session will begin on October 1.

University of London: Appointments

The following appointments have been made in the University of London: Dr. K. A. Hirsch, to the University readership in mathematics tenable at Queen Mary College; Mr. J. K. T. L. Nash, to the University readership in civil engineering tenable at King's College; Dr. Stanley Rowlands, to the University readership in physics tenable at St. Mary's Hospital Medical School.

The title of professor emeritus in the University has been conferred on the following in respect of the chairs they have held at the colleges mentioned: Prof. M. E. Delafield (chemistry as applied to hygiene, London School of Hygiene and Tropical Medicine); Prof. H. F. Hallett (philosophy, King's College); Prof. M. F. Lucas Keene (anatomy, Royal Free Hospital School of Medicine); Prof. J. R. Partington (chemistry, Queen Mary College); Prof. A. V. Hill (physiology and head of the Biophysics Research Unit, University College); Prof. D. M. S. Watson (Jodrell chair of zoology and comparative anatomy, University College); Prof. H. E. Watson (Ramsay chair of chemical engineering, University College).

The following doctorates have been conferred: *D.Sc.*: Mr. W. B. Mann (Imperial College of Science and Technology); *D.Sc.(Econ.)*: Mr. R. H. Coase (London School of Economics and Political Science).

Colonial Service: Recent Appointments

THE following appointments have recently been made in the Colonial Service: J. Cofie (senior agricultural officer, Gold Coast), senior assistant secretary, Gold Coast; N. Lamont (agricultural officer, Fiji), economic botanist, Fiji; G. M. Roddan (director of agriculture, Nyasaland), director of agriculture, Kenya; J. O. Torto (assistant director of agriculture (cocoa industry, temporary), Gold Coast), senior assistant secretary, Gold Coast; W. T. S. Brown (conservator of forests, Gold Coast), deputy chief conservator of forests, Gold Coast; D. A. Cannon (senior pathologist, Nigeria), assistant director of laboratory services, Nigeria; A. Kertesz (medical officer, Nigeria), pathologist, Nigeria; Dr. J. Anderson (senior veterinary research officer, Kenya), assistant director of veterinary research, Kenya; G. D. N. Bartlett (agricultural assistant, Nyasaland), principal agricultural assistant, Nyasaland; R. Elliott (entomologist, Sierra Leone), entomologist, Nigeria; C. D. Hutchings (senior agricultural officer, Jamaica), deputy director of agriculture (Extension Services), Jamaica; F. F. Smithyman (agricultural assistant, Nyasaland), principal agricultural assistant, Nyasaland; Dr. R. A. Kenney, senior scientific officer (physiologist), Heat Research Unit, Nigeria; D. A. Brown, veterinary officer, Kenya; P. D. Berwick, meteorologist, East Africa High Commission; H. T. Hayes, fisheries officer, East Africa High Commission; A. B. Law, meteorological officer, Northern Rhodesia; R. T. Smith, sociological research officer, British Guiana; J. E. Stevens, senior meteorological officer, Northern Rhodesia; T. Trimble, meteorological assistant, East Africa High Commission; W. R. Bransby-Williams, field officer, Colonial Insecticides Research Unit, East Africa.

The Night Sky in August

NEW moon occurs on Aug. 2d. 22h. 39m., U.T., and full moon on Aug. 17d. 02h. 59m. The following conjunctions with the moon take place: Aug. 1d. 04h., Mars 3° S.; Aug. 5d. 07h., Mercury 2° S.; Aug. 5d. 21h., Venus 4° S.; Aug. 7d. 02h., Saturn 4° N.; Aug. 20d. 21h., Jupiter 5° S.; Aug. 30d. 0h., Mars 2° S. Mercury is an evening star, setting about an hour before the sun on Aug. 1, but it draws closer to the sun and is in inferior conjunction on Aug. 31, and is not favourably placed for observation during most of the month. Venus sets about an hour after the sun on Aug. 1, but as the planet is approaching the sun it is not well placed for observation throughout the greater part of the month. Mars rises about 2h. 30m. during August and can be seen for some time before sunrise in the constellation Gemini. Jupiter rises at 22h., 21h. and 20h. on Aug. 1, 15 and 31, respectively, and is visible a little south of δ and ϵ Piscium throughout the month, stellar magnitude $-2{\cdot}3$. Saturn, an evening star, sets about $1\frac{1}{2}$ hours after sunset on Aug. 1 but draws closer to the sun and is not easily seen at the end of the month, when it sets less than an hour after sunset. Occultations of stars brighter than magnitude 6 are as follows: Aug. 4d. 11h. 18m., α Leonis (*D*); Aug. 4d. 12h. 32·6m., α Leonis (*R*); Aug. 23d. 01h. 29·3m., μ Arie. (*R*). (*D*) and (*R*) refer to disappearance and reappearance, respectively, and the times refer to observations made at Greenwich. The Perseid meteors attain a maximum about Aug. 10–12, but moonlight will make observations of the shower somewhat difficult.

Announcements

THE honorary degree of LL.D. of the University of Aberdeen has been conferred on Sir William Ogg, director of Rothamsted Experimental Station, Harpenden, Herts.

HONORARY degrees of the University of Reading have been conferred on the following: *D.Litt.*, Sir John Beazley, professor of classical archæology in the University of Oxford, and Sir Frank Stenton, formerly vice-chancellor of the University of Reading; *D.Sc.*, Sir John Russell, formerly director of Rothamsted Experimental Station, and Sir Henry Tizard, chairman of the Advisory Council on Scientific Policy.

THE honorary degree of D.Sc. of the University of Wales has been conferred on Sir David Brunt, professor of meteorology in the Imperial College of Science and Technology, London.

THE following appointments have been made in the University of Leeds: Dr. R. P. Hullin, lecturer in biochemistry; Mr. W. S. Reith, research chemist and honorary lecturer in the Department of Botany.

POWER Jets (Research and Development), Ltd., have appointed Mr. G. C. R. Mathieson to be senior lecturer at the School of Gas Turbine Technology, Farnborough, Hampshire. Mr. Mathieson was until recently a senior scientific officer in the Aerodynamics Department of the National Gas Turbine Establishment, Pyestock, which he joined in 1946.

SIR ALEXANDER CARR-SAUNDERS has resigned from the chairmanship of the Colonial Social Science Research Council, owing to the pressure of other duties; he will be succeeded by Sir David Parry, professor of English law in the University of London since 1930. Sir Alexander has recently assumed the chairmanship of the Inter-University Council for Higher Education in the Colonies.

THE Annual Exhibition of the Amateur Entomologists' Society will be held on Saturday, September 22 (2 p.m. to 6 p.m.), at Buckingham Gate Central Schools, Wilfred Street, London, S.W.1. There will be exhibits of specimens, equipment, apparatus, photographs, etc., and talks by experts including Major Maxwell Knight. Further particulars can be obtained from the honorary publicity secretary of the Society, L. W. Siggs, 10 Repton Road, Orpington, Kent.

INTERNATIONAL CO-OPERATION IN THE ANALYSES OF THE DEEP-SEA CORES COLLECTED BY THE SWEDISH DEEP-SEA EXPEDITION 1947–48

By C. D. OVEY
British Museum (Natural History)

I RECENTLY had the good fortune to be the guest, for a few days, of Prof. Hans Pettersson, leader of the Swedish Deep-sea Expedition 1947–48, and several of his research workers in Sweden. It is evident that it will not be long now before many important results of the work on the Expedition's deep-sea cores, collected by Dr. B. Kullenberg with his piston core sampler, appear in print in that country. The chemical and biological analyses are being carried out with extreme care by a well-organized group of workers, partly at the Oceanografiska Institutet in Göteborg and partly in Stockholm, and at Grödinge where Mr. Gustav Arrhenius has a number working under his direction on cores from the Eastern Pacific.

The Oceanografiska Institutet is the 'homè' of the investigations, whence the material is distributed. Both there, where mostly Central and Western Pacific and Indian Ocean material is being dealt with, and at Grödinge, the cores are carefully stored in cold air-proof rooms at a temperature of 5° C. in the presence of formalin. These precautions prevent shrinkage, cracking and drying, and ensure against bacterial action in the sediments which would cause oxidation of the manganese. Chemical tests are being carried out on the content of phosphorus, nitrogen, titanium, iron, nickel, vanadium, carbon and calcium carbonate. Tests of grain size are also being undertaken by Mr. Arrhenius. As with the single Atlantic core now being examined in the British Museum (Natural History) by my colleague, Dr. J. D. H. Wiseman, and I, it has been found by Mr. Arrhenius that the carbon dioxide content in Pacific cores is a reciprocal of the adsorbed water content. It is also agreed that a high percentage of carbon dioxide, which is derived from carbonate, is a reflexion of the productivity of the foraminifera which provided the material through the accumulated remains of their calcitic shells. Mr. Arrhenius has now given me a few samples from his Eastern Pacific cores, to discover whether warm-water foraminifera are abundant when the carbonate content is high in cores from that area, as has been shown to be true by the British Museum work on the Atlantic core already mentioned. It is hoped by co-operation of this sort to be able to link up the chemical work in Sweden, and its geological and hydrological implications, with the inferences of temperature changes of the surface layers of the ocean at present being made in Great Britain. It must be remembered that the results of the examination of the Pacific cores, shortly to be published, will cover a wide range of different hydrographic conditions through the comparison of a number of core-sections. The Pacific area samples, as shown by Dr. F. Koczy's work at Göteborg on the interpretation of echo-profiles and of the hydrographic properties near the floor in that area, indicate considerable vertical mixing due to the irregularity of the floor. From a study of the cores themselves, this is evidently as true of the past as it is of the present. The single Atlantic core being examined in Great Britain, however, suggests that deposition took place on the whole continuously and undisturbed, although there is some evidence of disturbance at a few depths due to bottom-living organisms. (I had the opportunity of examining part of the core at Göteborg and of seeing the log.) It therefore seems that the Atlantic core (No. 241 at 01° 10′ N., 19° 50′ W.), where the sedimentation was relatively undisturbed and the sea floor flat over a wide area, is ideal for the work on the interpretation of climatic change. The Pacific cores cannot be approached at this angle; but there is very good reason for supposing that, by application of the work done in Britain and the proof of the validity of planktonic foraminifera as temperature-indicators, temperature fluctuations will be traceable in the Pacific area.

One of the first of the Expedition's long cores was examined by Dr. F. B. Phleger, the first to apply foraminifera as temperature-indicators to this series. This core came from the Caribbean Sea, but it seems doubtful whether the local rate of sedimentation retained the constancy necessary for a close chronological problem. Nevertheless, Dr. Phleger has shown by his diagram that there were conspicuous and considerable variations in temperature in that area during the recent past.

As Prof. F. E. Zeuner ("Dating the Past", 2nd edit. 1950, p. 401) and Dr. J. D. H. Wiseman, in a recent address to the Society of Visiting Scientists, have implied, conclusions from single cores are tentative; but much will be learned as soon as Mr. Arrhenius publishes his work on the series of cores in the Eastern Pacific. Prof. Hans Pettersson was, however, very careful in his choice of core 241, which, although an isolated example, was obtained from a flat area of quiet undisturbed deposition. Further adjacent cores would naturally be of great value in establishing a standard for climatic variation in the equatorial Atlantic, but I wish to emphasize that it is my considered opinion and that of my colleague, Dr. Wiseman, that this particular core is singularly suitable for this purpose.

In Stockholm, Dr. R. W. Kolbe has been working with the diatoms of the Eastern Pacific cores and has provided Mr. Arrhenius with a fascinating story on the size distribution of *Coscinodiscus nodulifer* A. Schmidt. Dr. F. Brotzen is making a study of the benthonic foraminifera from cores in the same area. I was in complete agreement with him in the identity of the planktonic species which I am using as temperature-indicators. Interesting studies of radiolaria from Western Pacific cores by Mr. W. Riedel will be of great importance when linked with other work. His results, showing the presence of Tertiary forms, will be in print shortly.

Prof. Pettersson himself is conducting radioactive determinations on cores from the Cer tral and Western Pacific Ocean, but this is a long and tedious operation. Carbon-14 tests, being made on the Eastern Pacific cores, will be of first-class importance; but unfor-

tunately tests for this operation are done at the expense of considerable material, as it is necessary to use a large quantity for each count.

The above impressions are merely a very brief summary of the work now being carried out in Sweden on the material collected by the Swedish Deep-Sea Expedition, and in no way has space allowed for a complete survey. Let it be said that Prof. Pettersson has succeeded in building up a great network of scientific research on his cores both in Sweden, in north-west Europe, in Great Britain and in the United States. Every core, whether isolated or one of a group or sequence, is of value from some aspect of the deep-sea floor, which is so little known. It is not possible at this early stage to assess the worth of the work, whether geophysical, geochemical, biological or palæoclimatological. It is, however, evident even at this early stage that, whatever the aspect of approach, the whole will gradually be dovetailed into a preliminary story which will be a guide to future workers and explorers in this field in the same manner that the great *Challenger* Expedition of the last century became the foundation of oceanographical work to the present generation of marine investigators. We must therefore look forward with hope to co-ordinating this work further in August at the meeting of the Association d'Océanographie Physique in Brussels. It is essential to encourage co-operation in all the varied lines of study of the cores, because, however great the difficulties in obtaining sufficient financial assistance for this all-important work, collaboration, and not rivalry, is of prime importance; without it, what little money that is at present available would largely be wasted.

AN EXTRA-ADRENAL ACTION OF ADRENOTROPIC HORMONE

By Prof HANS SELYE

Institute of Experimental Medicine and Surgery, University of Montreal

JUST fifteen years ago, I described in this journal the 'general-adaptation-syndrome' as the somatic expression of "the response to damage as such". It was surprising that all organs of the body show degenerative changes, with widespread pyknosis and catabolism, under the influence of various damaging agents; only the adrenal cortex exhibits signs of increased hormone secretion and cellular proliferation. This was ascribed to the increased production of 'adrenotropic hormone', now generally known as ACTH[1]. These observations lead us to the concept that non-specific damage, or 'stress', has its own physiology and pathology (quite apart from specific actions of the agent used to produce stress) and that the pituitary-adrenal system plays a cardinal part in this non-specific adaptive or defensive reaction[2,3].

Subsequent investigations showed that the acute thymus involution, which occurs during the first 'alarm-reaction' stage of the general-adaptation-syndrome, is prevented by suprarenalectomy, while active adrenocortical extracts can produce thymus involution, even in the adrenalectomized animal. Hence, I concluded that "the secretion of the adrenal gland must therefore be considered essential for the ability of the thymus to undergo sudden involution"[4]. Since after hypophysectomy stress causes neither adrenocortical stimulation nor thymus involution, it was thought that the thymolysis is elicited by stress through the discharge of adrenotropic hormone and the consequent increase in the production of corticoids[3].

The numerous pertinent reports, published during the intervening years, appeared to support this concept; indeed, it is now generally held that not only the thymolytic, but also all known actions of adrenotropic hormone are mediated through the hormones of the adrenal cortex, because adrenotropic hormone produces no obvious changes in adrenalectomized animals, or in patients with complete adrenal destruction[5].

Recent experiments revealed that many of the actions of somatotrophic hormone are likewise abolished by adrenalectomy and can be restored, even in adrenalectomized animals, by suitable treatment with corticoids (Selye, in the press). This raised the question whether some of the supposedly trans-adrenal actions of adrenotropic hormone might not also be direct, though dependent upon the simultaneous presence of corticoids in the body fluids. The results to be reported here show that such a peripheral synergism between adrenotropic hormone and corticoids does, in fact, exist. Concurrent treatment with adrenotropic hormone and cortisone caused pronounced thymolysis in the adrenalectomized rat, although each of these hormones given separately failed to do so at the same dose level.

Experimental procedure. Three experiments have been performed on a total of 120 female piebald rats. In each of these we used four groups of ten rats treated respectively as follows: (I) hypertensinogen: (II) adrenotropic hormone; (III) adrenotropic hormone and cortisone; (IV) hypertensinogen and cortisone. Hypertensinogen was administered merely in order to determine the possible effect of a non-hormonal foreign protein. It was given at a daily dose-level of 6 mgm., administered in the form of six subcutaneous injections of 1·0 mgm. in 0·1 ml. of saline, subcutaneously every four hours. Adrenotropic hormone (ACTH, Connaught Laboratories, Toronto, Lot No. 2–2, 3–1) was given at the same dose-level and in the same manner as the hypertensinogen. It will be recalled that in order to obtain maximal adrenocorticotrophic effects from adrenotropic hormone, it is essential to give it at short intervals; it is for this reason that injections were given every four hours during the day and night. Cortisone was administered in the form of one subcutaneous injection of 0·5 mgm. a day, in the form of a microcrystalline suspension (as distributed by Merck and Co., Ltd., Montreal) which contains 5 mgm. of cortisone acetate per ml.

All the experimental animals in the three series were bilaterally adrenalectomized and ovariectomized forty-eight hours before the initiation of the injections. Immediately after this, they were given 1 per cent sodium chloride instead of tap water as a drinking fluid. The removal of the gonads and adrenals was necessary in order to eliminate both the known endogenous sources of steroid hormones.

The three experimental series differed only in that injections were given in the first experiment during four days, in the second during six days, and in the third during nine days. At the end of each experiment the animals were killed by exsanguination and their thymus glands removed for weighing and histological study.

Table 1. Effect of Four Days Treatment

Treatment		Hypertensinogen	ACTH	ACTH + cortisone	Hypertensinogen + cortisone
Body-weight (gm.)	Initial	121	121	121	121
	Final	117	109	114	120
Weight of thymus	in mgm.	366	319	203	282
	in mgm./100 gm. body-weight	308±18·5	294±16·1	179±15·9	237±18·1

Table 2. Effect of Six Days Treatment

Treatment		Hypertensinogen	ACTH	ACTH + cortisone	Hypertensinogen + cortisone
Body-weight (gm.)	Initial	108	108	108	107
	Final	109	104	104	109
Weight of thymus	in mgm.	299	291	161	249
	in mgm./100 gm. body-weight	275±23·5	280±21·8	156±13·7	228±17·4

Table 3. Effect of Nine Days Treatment

Treatment		Hypertensinogen	ACTH	ACTH + cortisone	Hypertensinogen + cortisone
Body-weight (gm.)	Initial	110	110	110	109
	Final	129	108	118	131
Weight of thymus	in mgm.	423	303	168	283
	in mgm./100 gm. body-weight	324±18·1	280±15·6	141±16·4	217±12·6

Results. The details of the experimental arrangement, the initial and final body-weights, as well as the thymus weight expressed in mgm. and in mgm. per 100 gm. of body-weight (the latter with its standard error) are given in the accompanying tables.

It will be noted that none of the injected materials caused a significant loss of body-weight during our short-term experiments. Neither adrenotropic hormone nor an equivalent amount of non-hormonal protein (in the form of hypertensinogen) produced any consistent and significant involution of the thymus in these adrenalectomized rats. Cortisone, when given in conjunction with hypertensinogen, induced only a moderate degree of thymolysis. However, in all three series, marked involution of the thymus was noted in the animals given adrenotropic hormone and cortisone. Statistical analysis of the apparent differences between groups III and IV showed that in all three series the augmentation of cortisone thymolysis by adrenotropic hormone was significant. The value of P, in comparing the thymus weights in mgm. per 100 gm. between groups III and IV, was $< 0{\cdot}05$ in group I, and $< 0{\cdot}01$ in groups II and III.

Histological studies essentially confirmed the observations made by mere weighing of the thymus in that maximal thymolytic phenomena were noted in groups III of all three series.

Discussion. These data indicate that adrenotropic hormone can synergize the thymolytic effect of a corticoid hormone, such as cortisone, even in the absence of the adrenal cortex. It follows that the thymolytic effect of stressor agents is not necessarily due to increased production of corticoids through discharge of adrenotropic hormone, but that it may in part also result from a peripheral synergism between the hormone and the corticoids.

These findings call to mind certain observations made in this Institute by Dr. Herlant[6], who showed that the thymolytic effect of threshold doses of adrenocortical extract is increased by an alarm-reaction, even in adrenalectomized rats. The present observations suggest that this increase may have been due, at least in part, to an endogenous discharge of adrenotropic hormone by the pituitary of the animal exposed to stress.

It remains to be seen whether a disproportion between circulating adrenotropic hormone and corticoids can produce results qualitatively different from those normally elicited by either of these hormones, and whether conjoint treatment with the hormone and cortisone would be of special benefit in the treatment of those lymphatic, inflammatory and allergic diseases which respond favourably to glucocorticoids.

These investigations were supported by a grant from the National Cancer Institute of Canada. I am also indebted to Miss Marguerite Parent for technical assistance. [May 8.

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ANTITUBERCULOUS EFFECT OF CERTAIN SURFACE-ACTIVE POLYOXYETHYLENE ETHERS IN MICE

By Dr. J. W. CORNFORTH, Dr. P. D'ARCY HART, R. J. W. REES and J. A. STOCK

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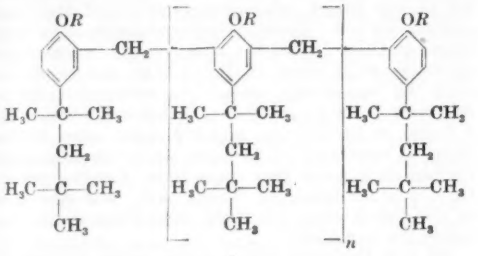
As part of a study, by two of us (P. D'A. H. and R. J. W. R.), of factors influencing the susceptibility of mice to experimental tuberculosis, methods of altering the body lipids were sought. For this purpose a new technique[1-3], by which the blood cholesterol and phospholipids could be maintained at high levels for several weeks by the repeated intravenous injection of the non-ionic surface-active agent 'Triton *A*20', was tried. This agent is described by its manufacturers (Rohm and Haas Co., Philadelphia; we are indebted to their associates, Charles Lennig and Co., Ltd., London, for supplies of the substance) as a 25 per cent aqueous solution of an arylalkyl polyether of phenol ('Triton *WR*1339'); and all doses of 'Triton *A*20' given below refer to this anhydrous material. In the first experiment, made more than a year ago, 'Triton *A*20' produced a striking suppressive effect on the course of a moderately acute tuberculous infection in mice. Further experiments amply confirmed this unexpected observation. 'Triton *A*20' has, however, undesirable toxic effects in mice. Injection of the optimal intravenous chemotherapeutic doses (15–25 mgm.) is followed immediately by convulsions, though these are transitory and seem to leave no after-effects; while

a single injection of 25 mgm. intraperitoneally or 10 mgm. subcutaneously produces a gelatinous ascites or œdema, respectively, and the highest daily dose (2·5 mgm.) tolerated by these routes without apparent ill-result gives only moderate protection. We therefore set out to synthesize and test biologically a series of compounds of similar chemical structure.

Synthesis of Test-Substances

The preparation of substances analogous to Triton *A*20' was based on an examination of the chemical properties of this detergent. Products of this type are referred to in U.S. Patent No. 2,454,541. In our first experiments, *p-tert*-octylphenol was condensed with formaldehyde, and the resulting mixture of condensation products was heated with ethylene oxide and a little alkali in an autoclave. In this way, a water-soluble, non-ionic, surface-active agent was obtained. Its structure can be expressed by the general formula (I):



I

$R = -CH_2CH_2O(CH_2CH_2O)_{18-15}CH_2CH_2OH$ except where indicated otherwise.
$n = 0$, 1, 2, 3 and higher integers.

This product (*D*2) was found to be as active chemotherapeutically as 'Triton *A*20' (see below), and it was therefore decided to prepare products homogeneous with respect to n. Condensation of *p-tert*-octylphenol with ethylene oxide gave a toxic product (*D*3). 2 : 2'-Dihydroxy-5 : 5'-di-*tert*-octyldiphenylmethane (I; $n = 0$; $R = H$) was made from excess *p-tert*-octylphenol and formaldehyde by adapting a conventional method. Condensation of this crystalline substance with ethylene oxide afforded the product *D*4 (I; $n = 0$). *p-tert*-Octylphenol with formaldehyde and sodium hydroxide gave 2 : 6-*bis*hydroxymethyl-4-*tert*-octylphenol[4] and, contrary to an earlier statement[5], no difficulty was experienced in condensing this substance with excess *p-tert*-octylphenol to give 2 : 6-di(2'-hydroxy-5'-*tert*-octylbenzyl)-4-*tert*-octylphenol (I; $n = 1$; $R = H$) which, though non-crystalline, could be purified by distillation at a pressure of 10^{-2} to 10^{-3} mm. mercury. This compound was condensed with ethylene oxide to give *D*9*a* (I; $n = 1$).

Condensation of the substituted diphenyl methane (I; $n = 0$; $R = H$) with formaldehyde in glacial acetic acid saturated with hydrogen chloride (cf. refs. 5, 6), and subsequent molecular distillation of the reaction mixture after elimination of excess parent compound, gave a product consisting essentially of the tetracyclic compound (I; $n = 2$; $R = H$) which reacted with ethylene oxide to give *D*10*a* (I; $n = 2$). The residue in the molecular still was also condensed with ethylene oxide, giving *D*10*b* (I; $n = 4$, 6, 8, etc., together with unexpelled tetracyclic compound). For comparative biological tests, *D*10 (I; $n = 2$, 4, 6, etc.) was prepared from a resin obtained exactly as above except that molecular distillation was omitted.

In another experiment and as a possible alternative to molecular distillation, an attempt was made to purify the crude tetracyclic compound by successive countercurrent distribution between ligroin (boiling range 88°–101°) and 94 per cent aqueous ethanol at 0° C. Only a partial purification resulted, but the best fraction was condensed with ethylene oxide; the product (*D*11) showed activity similar to that of *D*10*a*.

The product isolated by a double molecular distillation of another batch of the crude tetracyclic compound was also shown by countercurrent distribution to be not quite homogeneous.

Finally, 2 : 6-*bis*hydroxymethyl-4-*tert*-octylphenol was condensed with excess of the substituted diphenyl methane (I; $n = 0$; $R = H$). A product, collected at 300°–310° in the molecular still, was presumably mainly the pentacyclic compound (I; $n = 3$; $R = H$). This gave *D*12 (I; $n = 3$) on condensation with ethylene oxide.

The results given below show that no activity can be observed in the products when n is less than 2. The presence of the di- and tri-cyclic compounds in mixtures such as *D*2 appears to have no advantage. On removing these substances as completely as possible by distillation from the resin corresponding to *D*2 and condensing the residue with ethylene oxide, the product (*D*2*a*; I; $n = 2$, 3, 4, etc.) was found to be as active as *D*2.

Bacteriostatic Tests

Paradoxically, in the light of the chemotherapeutic results to follow, 'Triton *A*20' was suggested[7] as a useful addition to fluid media for the culture of tubercle bacilli, since it promoted dispersed growth of virulent organisms (strain *H*37*Rv*); optimal concentrations were 0·1–0·01 per cent and there was neither inhibition nor enhancement of growth in this range. We have confirmed the dispersive properties, but observed an increasingly bacteriostatic effect on strain *H*37*Rv* at concentrations greater than 0·1 per cent. Other workers[8] have reported an enhancing effect of 'Triton *A*20' on the growth of tubercle bacilli at lower, and an inhibitory action at higher, concentrations; the inhibitory range extended as the *p*H was increased. *D*3 did not permit growth of *H*37*Rv* at 0·01 per cent; our other products, whether active or inactive against infection with this strain in mice (see below), were less inhibitory to its growth *in vitro* than 'Triton *A*20', but were similarly dispersive. No bactericidal action on *H*37*Rv* by 'Triton *A*20' 0·1 per cent and 1·0 per cent at *p*H 6·8–6·6 was evident after 20 hours exposure.

Chemotherapeutic Tests

The chemotherapeutic assessment is illustrated by a typical experiment. Twenty-two female mice of the albino Parkes strain, weighing 18–20 gm., and fed on a stock mash diet, were infected intravenously with 0·06 mgm. dry weight (about 10^7 viable organisms) of *Mycobacterium tuberculosis*, strain *H*37*Rv*, grown in 'Tween 80'-albumin medium. Starting the next day, ten of the mice received intravenous injections of 25 mgm. of *D*2 in 0·2 ml. saline twice weekly for two weeks, the injections being given slowly; the other twelve mice served as an untreated control. The control mice lost weight, and nine of the twelve died with gross pulmonary tuberculosis

between 18 and 26 days after infection (median survival time 23 days); one died of intercurrent infection on the fifth day; and the two remaining animals, which were sick, were killed on the thirty-fourth day and their lungs showed well-marked tuberculous lesions. In contrast, apart from one death from intercurrent infection also on the fifth day, none of the ten treated mice died; they gained weight and appeared healthy when they were killed on the thirty-fourth day, that is, twenty-three days after the last injection; and they had air-containing lungs showing in eight of them scattered tuberculous lesions, pin-point in size, and varying in number, and in the ninth animal somewhat more advanced changes.

Using the same test, the following preparations, at the doses stated, had a similar order of anti-tuberculous activity to *D*2: 'Triton *A*20' (15–25 mgm.), *D*2*a* (25 mgm.), *D*10 (25 mgm.), *D*10*a* (15 mgm.), *D*10*b* (25 mgm.), *D*11 (15 mgm.) and *D*12 (25 mgm.). On the other hand, given at the following maximum tolerated doses, *D*4 (5 mgm.) and *D*9*a* (7·5 mgm.) were inactive. When the twice-weekly intravenous dose of 'Triton *A*20' was reduced to 10, 5 and 1 mgm., none of the three series of animals showed deaths from tuberculosis during the experiment, but the pulmonary lesions on killing were increasingly severe. The results obtained were as effective when the course of treatment with 'Triton *A*20' (25 mgm.) was started five days as one day after infection, and even a single dose at five days profoundly reduced the mortality and the lung lesions. Moreover, although individual animals failed to receive one or more doses after the first, in the usual course of four, owing to difficulties in repeatedly injecting the tail vein, this seemed to make little or no difference to the therapeutic results. When the usual course of 'Triton *A*20' (15 mgm.) was started ten days after infection, no protection was evident. Streptomycin, 2,000 units daily subcutaneously, gave results similar to 'Triton *A*20', 15 mgm. and 5 mgm. twice weekly intravenously, both drugs being started on the day after infection and administered for two weeks. When, however, the type of experiment was varied by killing about eight (instead of three) weeks after cessation of treatment, most of the streptomycin-treated mice had died of chronic pulmonary tuberculosis, whereas the animals treated with 'Triton *A*20' (15 mgm.) were still alive though their lungs showed that the infection had progressed. An experiment in which 2·5 mgm. of 'Triton *A*20' was given daily subcutaneously for two weeks, from the day after infection, resulted in similar protection against death to that given by 15 mgm. twice weekly intravenously, but the pulmonary lesions on killing (34 days) were more advanced in the majority of the animals.

Pharmacology and Toxic Effects

We have confirmed the observation[1–3,9] that intravenous injection of 'Triton *A*20' is followed by a rise in blood cholesterol, associated, when the rise is considerable, with milky serum. Estimations made two days after the end of a two weeks course of twice-weekly injections of 25 mgm. in mice showed a four- or five-fold increase in blood cholesterol, with milky serum, the levels returning to normal in about a week; with doses of 10 mgm. and 5 mgm. there was a two-fold and no increase, respectively. Blood cholesterol estimations were not made after giving our own products, but milky serum was observed at 24–48 hr. after a single intravenous injection of 15–25 mgm. of all that could be given at these doses, except *D*12. Similar hyperlipæmia was produced by the higher doses given by the intraperitoneal and subcutaneous routes. The adrenal glands from mice given a course of 'Triton *A*20' intravenously (15–25 mgm.) were pale pink, instead of the characteristic yellow. Histochemical tests showed the cortex to have been stripped of fat and cholesterol, these being apparently restored to normal in one or two weeks after cessation of treatment, the cholesterol more slowly than the fat. Sections of liver showed some decrease of fat, but the fat depots in general appeared unaffected. A similar temporary pallor of the adrenals was noted after one or more intravenous injections of most of our products, and subcutaneous and intraperitoneal administration with the larger doses also produced this phenomenon.

All the surface-active agents mentioned here have an ultra-violet absorption peak at 278 mμ, and this characteristic was used to estimate 'Triton *A*20' and *D*2 in the blood, after precipitation of the blood proteins by a 4 : 1 ethanol–ether mixture. The blood concentrations reached after single intravenous injections of 25 mgm. of 'Triton *A*20' were high, and their fall remarkably slow. The concentrations per ml. were 7 mgm. at 24 hr., 3 mgm. at two days, 2 mgm. at three days, and 0·8 mgm. even at four days. A course of *D*2 25 mgm. daily subcutaneously for ten days gave, four days later, 4 mgm. per ml. On the other hand, no 'Triton *A*20' was detectable in the blood after 100 mgm. had been given daily orally for a month.

*D*3 was the most toxic of the series to mice, its intravenous LD_{50} being 3 mgm. and death being immediate. For *D*4 and *D*9*a* the LD_{50} was 12·5 mgm. by this route. All but one of the other products were tolerated intravenously at doses varying from 15 mgm. to 75 mgm. without convulsions, in contrast to 'Triton *A*20', and without other serious symptoms; *D*12, however, was associated with transitory spasticity. Since *D*2 contained both *D*4 and *D*9*a* in proportions such as would have been expected to confer an appreciable toxicity, it would seem that admixture with the higher polymers had masked this. Further evidence of this phenomenon is provided by the comparative hæmolytic tests. None of our products tested intraperitoneally or subcutaneously at single 20–25 mgm. doses (*D*2, *D*2*a*, *D*10 and *D*12) gave rise to ascites or subcutaneous œdema, nor did *D*2*a*, *D*10 or *D*12 do so after seven to ten daily subcutaneous injections of these amounts. A more detailed examination was made on animals killed nine days after they had completed a course of 25 mgm. of *D*2 intravenously twice weekly for three weeks. They seemed healthy and had gained weight. At autopsy the principal organs were normal in appearance and size (except for the adrenals already described), and adipose tissue was normally distributed. Microscopically also, these organs showed no abnormalities; in particular, the liver cells showed no obvious degenerative changes, in contrast to the livers of animals treated with 'Triton *A*20', which often had small areas of focal necrosis. The livers appeared normal also in mice that had received courses of *D*2*a*, *D*10, *D*10*a* and *D*10*b* intravenously, but damage was seen in a small proportion after *D*11 and *D*12. We have not observed the presence in excessive quantities of 'foam cells' in the reticulo-endothelial systems of our animals, as described by Payne and Duff[10].

Serial No.	Chemical structure	Inhibitory concentration* (gm./100 ml.)	Chemotherapeutic activity	Intravenous toxicity		Hæmolytic ratio ('Triton *A*20'=1)
				LD_{50} in mgm.† (single injection)	Liver damage (course of injections of 15–25 mgm.)	
*D*2	I; $n = 0, 1, 2, 3$, etc.	1·0	+	>75·0	0	0·02
*D*2*a*	I; $n = 2, 3, 4$, etc.	1·0	+	>62·5	0	0·02
*D*3	*p*-Octylphenol polyoxyethylene ether	0·01	Too toxic for test	3·0		1,600
*D*4	I; $n = 0$	1·0	0	12·5		500
*D*9*a*	I; $n = 1$	>1·0	0	12·5	± (7·5 mgm.)	1·0
*D*10	I; $n = 2, 4, 6$, etc.	>1·0	+	>50·0	0	0·25
*D*10*a*	I; $n = 2$ (substantially)	>1·0	+	>50·0	0	0·25
*D*10*b*	I; $n = 4, 6$, etc. (and unexpelled I; $n = 2$)	>0·5	+	>25·0	0	0·25
*D*11	I; $n = 2$ (substantially)	>1·0	+	>25·0	±	
*D*12	I; $n = 3$ (substantially)		+	>50·0	±	
'Triton *A*20'		0·7	+	>25·0	±	1·0

* No growth at two weeks in synthetic medium containing 2·5 mgm. albumin and 0·0008 mgm. (moist weight) tubercle bacilli per ml.
† Mice weighed 18–20 gm. each.

'Triton *A*20' had a low hæmolytic activity *in vitro*, this finding being in agreement with other workers[11]. Tests with our products in comparison with this agent showed that *D*3 was 1,600, and *D*4 500, times as hæmolytic, while *D*9*a* had the same activity. The other products showed somewhat lower hæmolytic activities than 'Triton *A*20', particularly *D*2 and *D*2*a*, which gave values of one-fiftieth or less. Mouse serum was never seen to be pigmented even after the largest doses of 'Triton *A*20', or of any of the products that showed equal or lower hæmolytic activity *in vitro*. Capillary permeability tests with intravenous pontamine blue revealed a contrast between *D*4, which markedly increased leakage of the dye through the vessels into the tissues, and 'Triton *A*20', *D*2 and *D*2*a*, which showed no such effect.

Discussion

Within the limits of the present study, the products tend to be less toxic, and more active against tuberculous infection, as molecular size increases. Antituberculous activity in compounds of formula I may perhaps be limited to a definite range of values of n: it is worth noting that an increase of one unit in n raises the molecular weight by about 1,000.

Marked bacteriostatic activity *in vitro* was found only with the simplest compound (*D*3), which was too toxic to be tested chemotherapeutically. All our other products, both active and inactive *in vivo*, showed an approximately equal bacteriostatic power of a low order. It remains doubtful, therefore, whether direct bacteriostatic action is responsible for the antituberculous effect in mice, in spite of the high concentrations attainable in their blood. The relevance of the remarkable hyperlipæmia, and loss of lipids from the adrenal glands, to chemotherapeutic effectiveness is also doubtful, since 'Triton *A*20' was definitely antituberculous at doses too small to produce these phenomena, while they were not apparent even after the higher, and effective, doses of *D*12.

The detoxifying action of the higher polymers on the toxic lower members of the series, as well as their persistence in the blood, suggests the possibility of using these compounds in association with other, even toxic, drugs having high tuberculostatic activity *in vitro*.

Experiments are in progress with a method of reverse phase partition chromatography with the object of isolating the pure compounds containing four and more phenolic nuclei in the molecule. The substituents in the phenolic nuclei will also be varied. On the biological side, the reactions of the tissue white cells to these surface-active substances, and any possible antituberculous effect in animal species other than mice, will be investigated.

Some of this work is forming the subject of a patent application.

We are indebted to Dr. A. J. P. Martin for his advice in connexion with the partition chromatography.

Summary

The development of experimental tuberculosis in mice is markedly inhibited by injection of certain non-ionic, water-soluble, surface-active preparations of low toxicity, having the general formula I ($n > 1$), obtained by reaction of ethylene oxide with condensation products of formaldehyde with *p*-*tert*-octylphenol. Some of the more important results relating to these products are summarized in the accompanying table.

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RADIOCHEMICAL TECHNIQUES IN ANALYSIS

IN conventional radioactive tracer methodology a labelled substance is added to a system so that its physical or chemical fate in the system can be followed by its radioactivity. In this way radiochemical techniques have been more used as a research tool than as an aid to routine chemical analysis. There are several ways, however, in which radiochemical techniques may be effectively used in analytical chemistry, some of which were exemplified at the recent meeting organized by the Physical Methods Group of the Society of Public Analysts and Other Analytical Chemists. The meeting, under the chairmanship of B. S. Cooper, was held in the rooms of the Institute of Physics in London on

May 22. This 'radiochemistry meeting', which was the second to be held under that title, was well attended and very successful, and promises to become a useful annual event.

Four papers were presented at the meeting. The first, by F. P. W. Winteringham, A. Harrison and R. G. Bridges (Pest Infestation Laboratory), was read by the first author and described the application of radiochemical techniques to quantitative paper-chromatographic analysis. Radiochemical techniques have been so applied in three ways: (1) the mixture for analysis already contained labelled components as in tracer experiments, or it was exposed to a labelled reagent before chromatographic separation so that one or more of the components were converted into radioactive derivatives; (2) the finished paper chromatogram was exposed to a labelled reagent which combined selectively with one or more of the separated components, the excess of reagent then being removed, leaving a radioactive isotope either associated or combined with the components; (3) the finished paper chromatogram was irradiated in the Harwell Pile so that any components containing an element of suitable activation cross-section was made conspicuously radioactive. In all cases the labelled chromatograms were scanned radiometrically so that the labelled components could be located or estimated. A simple device was described in which uni-dimensional paper chromatograms or strips cut from a two-dimensional chromatogram were fed automatically at a controlled rate through a slot so that consecutive sections of the paper were exposed for a given time interval to a screened end-window Geiger–Müller tube under conditions of uniform geometry. By using a suitable integrating circuit connected to a pen-recording milliammeter or self-balancing potentiometer, the mean rate of count was plotted against the distance along the strip, giving the required radio-chromatogram. The effects of β-particle self-absorption by the paper, and its variation, have been calculated to be small and unlikely to impair quantitative work even with soft β-emitters like carbon-14 or sulphur-35. Several radiochromatograms, obtained by the methods discussed, were presented.

The second paper, by E. Lester Smith and D. Allison (Glaxo Laboratories), dealt with the paper chromatographic analysis of penicillin mixtures labelled with radioactive sulphur-35. Dr. Lester Smith described how crystalline penicillins containing up to 600 microcuries of sulphur-35 per mgm. were prepared biosynthetically in a medium containing sodium sulphate labelled with sulphur-35. A point of interest was that the mould *P. chrysogenum*, Q176, tolerated up to one curie of sulphur-35 per litre of medium. The penicillin mixture was resolved on a buffered paper chromatogram by the method of Goodall and Levi. The separated components were located or estimated by three methods and the results compared. In the first method (Goodall and Levi) the developed chromatogram was placed against an agar plate inoculated with *B. subtilis* so that on incubation the separated penicillins were located and estimated by the zones of bacterial inhibition. In the second method the strips were placed against X-ray film in the dark so that the components labelled with sulphur-35 could be located autoradiographically. Finally, the paper chromatogram was cut up into equal sections which were mounted below a thin end-window Geiger–Müller tube and the β-activity of the sulphur-35 assayed radiometrically. The results by all three methods agreed well, and the experiments demonstrated clearly the value of a radioactive tracer technique in checking existing chemical and biological methods of assay. An interesting outcome of these experiments was that a significant fraction of the penicillins appeared to be destroyed after application to the paper strip, this being suggested by a zone of radioactivity at the origin not associated with antibiotic activity.

A. A. Smales read the third paper, contributed by himself and B. D. Pate (Harwell), and described a method for the ultra-micro determination of arsenic by neutron activation. Pile irradiation of a sample containing arsenic gives rise to radioactive arsenic-76 by means of the reaction $^{75}As(n,\gamma)^{76}As$. Arsenic-76 decays by β-emission of maximum energy 3·0 MeV. with a half-life of 27 hr. Radiation due to this isotope in a chemically separated fraction is characterized by its energy and decay period. The sensitivity and accuracy of the method were tested by a carrier technique in which a known excess of inactive arsenic was added to the irradiated sample and a known proportion isolated by conventional analytical techniques, the activity of arsenic-76 in the separated fraction then representing a known proportion of the arsenic originally present in the sample. Close agreement was obtained between chemical and activation analysis at high concentrations, and the results obtained by the activation method alone were consistent on samples diluted well beyond the limits of chemical detection. The data provide an excellent example of the sensitivity and accuracy of the methods of activation analysis. The determination of as little as 10^{-4} μgm. of arsenic in biological samples appears to be quite practicable. Their great sensitivity, notwithstanding the methods, are not without pitfalls for the unwary. This was illustrated in the application of the method to the assay of germanium dioxide for arsenic. On neutron activation, germanium itself gives rise to more than one radioactive isotope of arsenic—for example, by the sequence, $^{74}Ge(n,\gamma)^{75}Ge \xrightarrow{\beta} {}^{75}As(n,\gamma)^{76}As$, so that 'spurious' arsenic appears as a result of the irradiation. Arsenic-77, which also arises from germanium, may be distinguished radiometrically. Mr. Smales suggested that a similar difficulty might arise during the irradiation of samples rich in bromine or selenium, for example, by the reaction $^{79}Br(n,\alpha)^{76}As$.

The last paper was presented by R. D. Keynes (Cambridge), who described the application of the methods of activation analysis to the determination of sodium and potassium in biological samples. Samples for analysis were irradiated in the Harwell Pile together with samples of spectroscopically pure sodium carbonate and potassium bicarbonate which were used as reference standards. It was found that, during the irradiation of desiccated nerve fibres isolated from cuttle-fish, sodium-24, potassium-42, phosphorus-32 and sulphur-35 were the principal radionuclides formed, the last no doubt partly arising from the reaction $^{35}Cl(n,p)^{35}S$. Sodium-24 and potassium-42 arise by neutron activation of the natural isotopes, so that the corresponding radioactivities are a direct measure of the sodium and potassium originally present. By a simple screening technique the sodium-24 and potassium-42 were distinguished by their energetic γ- and β-emission respectively, and chemical carrier separation was unnecessary. A small correction had to be made for the phosphorus-32, which could be determined after the short-lived sodium and potassium isotopes had

decayed to insignificance. A modification in estimating the potassium only was to add a known excess of potassium carbonate carrier to the irradiated sample and, precipitating a known fraction of the total potassium as the dipicrylaminate, this salt was then radiometrically assayed separately. These methods have been used successfully on a routine basis for the determination of weights of the order of 0·5 μgm. of sodium and 5 μgm. of potassium in biological samples. The results indicate that as little as 0·05 μgm. of sodium can be estimated to within a few per cent, so that the potentialities of the method in chemical analysis are obvious.

It would not be appropriate to record here more than a few points raised in the ensuing discussion. R. C. Chirnside asked if the decomposition of the penicillins noted during the paper chromatography of the labelled material minimizes the value of the Goodall and Levi method; Dr. Lester Smith replied that, unless the relative decomposition of the individual penicillins was unequal, the value of the original method would not be affected because it was used to show the proportional composition of the penicillin mixture rather than the individual weights. J. Haslam asked if the method of radioactivation analysis can be applied to the determination of iodine in sea water, to which Mr. Smales replied that the relatively short half-life of the iodine-128 produced by neutron activation of natural iodine makes the determination very difficult, since any separation and counting would have to be completed within a matter of two or three hours of removing the sample from the pile; however, Mr. Smales mentioned that the determination of a range of trace elements in water by radioactivation analysis is, in fact, being investigated. A. C. Mason wondered if the methods could be used for the determination of boron in plant material—a difficult problem in chemical analysis—and Mr. Smales replied that boron unfortunately gives rise to no suitable isotope on neutron irradiation. Other items discussed ranged from the particular advantages to be expected as a result of combining radioactive tracer techniques with paper chromatography to the use of radioactivation analysis for the detection of arsenic in poisoned victims.

F. P. W. Winteringham

UNIVERSITY OF GLASGOW

FIFTH CENTENARY CELEBRATIONS

ON the evening of June 29, the last of a series of 'At Homes' in the Bute Hall at the University brought the celebrations of the fifth centenary of the University of Glasgow to a close. They began almost a fortnight before with the arrival on June 17 and 18 of nearly two hundred delegates representing universities and other learned bodies in all parts of the world, and of many other distinguished scholars invited to receive honorary degrees.

On the afternoon of Monday, June 18, the guests were welcomed informally at faculty receptions in the College Rooms and Queen Margaret Union, and renewed or established friendships which were strengthened by the academic and social functions of the ensuing days. That evening many guests attended the first McEwen Memorial Concert in the Hunter Hall.

On Tuesday, June 19, a very full programme began with the presentation of addresses in the Bute Hall, when delegates, representatives and graduands from at home and abroad were welcomed by the Chancellor, Lord Boyd-Orr. Before a full assemblage of the Senatus, academic staff and honorary doctors of the University, the guests bringing messages of greeting were called in turn and handed their greetings to the Chancellor. More than two hundred such messages were presented, all graciously worded and many of them beautifully illustrated. They have been on display to the public, together with many other addresses received by post, in the Upper Library throughout the period of the celebrations, and have attracted many visitors.

One of the most colourful and impressive ceremonies took place on the Tuesday afternoon when, in robed processions, delegates, graduands and the Chancellor, Court and Senate of the University went in bright sunshine from the Royal Infirmary to the Commemoration Service in Glasgow Cathedral, the first home of the University congregations five hundred years ago. The whole of the Cathedral quire was filled with the academic gathering, while wives and friends occupied the nave, an assemblage in all of some 1,200. The sermon was preached by the Minister of Glasgow, and others officiating were the Principal, the Professor of Divinity, the Clerk of the Senate, the Moderator of the General Assembly of the Church of Scotland and the University Chaplain. The music was played by the Professor of Music.

On Tuesday evening some eight hundred guests were entertained to dinner in two gatherings, one at the Central Hotel presided over by the Chancellor, and the other at the adjacent Grosvenor Restaurant where the chairman was the Rector. It was a happy circumstance that the Prime Minister, who was to receive the next day the honorary degree of Doctor of Laws, and Mrs. Attlee arrived in time to be present. Among the speakers were the Lord Justice General, the President of the University of California, the Lord Bishop of Durham, Sir Oliver Franks, the Principal of McGill University, Prof. F. L. Ganshof, of the University of Ghent, Prof. J. M. Holst, of the University of Oslo, and Prof. M. Le Breton, of the University of Paris.

The mornings of June 20 and 21 were reserved for the two major academic functions, the honorary graduation ceremony and the commemoration oration by Lord Macmillan of Aberfeldy respectively. For these functions some 2,700 persons assembled on each occasion in St. Andrew's Hall, almost half of them in academic robes. The colourful splendour on each occasion was perhaps unprecedented in the history of the University or of the city.

At the graduation ceremony twelve honorary degrees of Doctor of Divinity and fifty-four of Doctor of Laws were conferred. Among those receiving the degree of LL.D. were the following: Prof. E. D. Adrian, professor of physiology in the University of Cambridge; Prof. A. C. Aitken, professor of mathematics in the University of Edinburgh; The Right Hon. C. R. Attlee, Prime Minister; Sir John Beazley, professor of archæology in the University of Oxford; Prof. Niels Bohr, professor of theoretical physics in the University of Copenhagen; Sir John Cockcroft, director of the Atomic Energy Research Establishment, Harwell; Sir John Craig, steelmaker in Glasgow; Dr. H. W. Dodds, president of Princeton University; Dr. R. Dohrn, director of the Zoological Station at Naples; Dr. P. J. Du Toit, president of the South African Council for Scientific and Industrial Research; Prof. T. G. Halle, professor of palæobotany in the University of Stock-

holm; Prof. B. A. Houssay, formerly professor of physiology in the University of Buenos Aires; Prof. F. H. Knight, professor of social sciences in the University of Chicago; Prof. H. R. Kruyt, formerly professor of physical chemistry in the University of Utrecht; Prof. E. O. Lawrence, professor of physics in the University of California; N. A. MacR. MacKenzie, president of the University of British Columbia; Sir Arcot Mudaliar, vice-chancellor of the University of Madras; Prof. J. Ortega y Gasset, formerly professor of philosophy in the University of Madrid; Lord Reith of Stonehaven; Prof. D. S. Russell, professor of pathology in the University of London; Prof. L. S. Ruzicka, professor of organic chemistry in the Swiss Federal Institute of Technology; Prof. René Sand, professor of social medicine in the University of Brussels; Prof. G. G. Simpson, professor of vertebrate palæontology in Columbia University; Prof. Norman Kemp Smith, formerly professor of logic and metaphysics in the University of Edinburgh; Prof. J. G. Sölch, professor of geography in the University of Vienna; Sir Richard Southwell, formerly rector of the Imperial College of Science and Technology, University of London; Prof. S. Timoshenko, professor of mechanics in Stanford University; Prof. O. Veblen, formerly professor of mathematics in the Institute for Advanced Study at Princeton; Prof. C. E. Weatherburn, professor of mathematics in the University of Western Australia; and Prof. G. H. Whipple, professor of pathology in the University of Rochester. The speakers on behalf of the new graduates were the Bishop of Strängnäs, Lord Reith, the president of Princeton University and the president of the University of British Columbia. The new and past doctors and their wives were afterwards entertained to luncheon in the Bute Hall by the Chancellor, Court and Senate, when replies to the toast of "The New Graduates" were made by Prof. C. H. Dodd, of Cambridge, and Prof. L. S. Ruzicka, of the Swiss Federal Institute of Technology.

The Wednesday programme was completed by two happy social functions at which Town and Gown mingled, an afternoon reception at the Trades House by the Deacon-Convener of the Trades of Glasgow and the Collector of the Trades House, and a reception in the evening at the City Chambers by the Lord Provost and Magistrates.

At the opening of the Oration Ceremony on June 12, the Chancellor expressed the regret of all that Their Majesties the King and Queen were unable to grace the gathering with their presence, and the Principal read an address from the University to the King and a gracious message from His Majesty. Lord Macmillan then delivered the Commemoration Oration, an eloquent tribute to the past achievements of the University and expression of the ideals which should guide its future. The conclusion of this ceremony, the last of the academic functions of the celebrations, was most fittingly the maiden speech of the Prime Minister as a doctor of the University of Glasgow. More than two thousand guests attended a reception at the University on the Thursday afternoon. In the evening, while their wives were the guests of Lady Hetherington at an 'at home' in the College Rooms, the delegates and new graduates were entertained to dinner by the Senate in the Grosvenor Restaurant. Robes and formalities were laid aside. The Principal presided and the speakers at the dinner included the Vice-Chancellors of the Universities of Cambridge and London, Dr. H. R. Kruyt of the Universities of Utrecht and Amsterdam, and Dr. B. Blanshard of Yale University.

On June 22, a precedent was followed that had been created fifty years before (almost to the day) on the occasion of the ninth jubilee, when the University took its guests for a cruise on the Firth of Clyde. As in 1901, it was a day of midsummer sunshine and the Firth a panorama of mellow beauty. The *Queen Mary II* sailed in the morning with eight hundred guests from Bridge Wharf in the centre of the city past the shipyards and Dunbarton Rock and cruised in the Kyles of Bute, Loch Striven and Loch Riddon, returning round the Cumbraes to Wemyss Bay, whence the journey to Glasgow in the evening was made by train. On the morning of June 23, some 150 guests who still remained were taken by coach to Loch Lomond.

The following week was reserved for gatherings of Glasgow's own graduates, and more than three thousand members of the General Council and their wives were entertained in the Bute Hall on June 25, 27, 28 and 29.

J. B. Neilson

AMERICAN PHYSICAL SOCIETY

ANNUAL MEETING

The 1951 annual meeting of the American Physical Society was held at Columbia University, New York City, during February 1–3. The annual meeting of the American Association of Physics Teachers took place simultaneously at Barnard College. At the joint session of the two bodies on February 2, the retiring presidential address of the Physical Society was delivered by Prof. I. I. Rabi, who took as his subject "Molecular Beam Researches in Nuclear and Electronic Physics"; the Oersted Medal of the Association was presented to Prof. J. W. Hornbeck (who died on February 27); and the tenth Richtmyer Memorial Lecture was delivered by Prof. J. C. Slater, who spoke on "The Electron Theory of Metals". The after-dinner speaker at the banquet in the evening was Prof. J. R. Oppenheimer, who spoke principally about meson theory.

At the business meeting of the Physical Society the following officers were elected: *President*, C. C. Lauritsen; *Vice-President*, J. H. Van Vleck; *Secretary*, K. K. Darrow; *Treasurer*, G. B. Pegram; *Managing Editor*, S. A. Goudsmit. The headquarters of the *Physical Review* have now been removed from the University of Minnesota, which housed them for the past quarter of a century, to the Brookhaven National Laboratory.

Twenty-eight invited papers, in addition to two hundred and ninety-one (a new record) ten-minute papers, were contributed to the meeting of the Physical Society. The invited papers included: a group of papers describing the Brookhaven National Laboratory and the research work carried on there; various papers on nuclear physics, including one by C. C. Lauritsen on the work on nuclear energy-levels at the California Institute of Technology; four papers mainly concerned with mesons; in the division of electron physics, J. A. Hornbeck on a review of positive-ion mobilities in the noble gases; in the division of fluid dynamics, E. Teller on magneto-hydrodynamics and G. Birkhoff on some modern problems in classical hydrodynamics; J. Bardeen on supraconductivity and lattice vibrations, and two contributions by English visitors, S. Chap-

man on some phenomena of the upper atmosphere and M. H. L. Pryce on nuclear hyperfine structure of paramagnetic resonance. A complete list of the papers, together with abstracts, is given in the minutes of the meeting, which are printed in the April 15 issue of the *Physical Review* (**82**, 291 ; 1951).

It was reported that the membership was 9,740, and that the income of the Society had exceeded expenditure by a substantial amount, but that there was little hope that the Society would be equally fortunate during 1951. A change in the by-laws was approved which empowered the Council to fix the terms on which members of the Society shall receive either *Physics Abstracts* or *Engineering Abstracts*. The subscription prices at which these journals are sold to the Society by the Institution of Electrical Engineers, London, have recently been raised, and the purpose of the amended by-law is to enable the Council to recover the extra cost. A committee was appointed to make recommendations about the future relations of the Society and *Science Abstracts*.

The minutes include a copy of the letter sent by Dr. D. W. Bronk, president of the National Research Council, on December 11, 1950, to R. L. Clark, the director of the Manpower Office of the National Security Resources Board, in which specific recommendations with regard to the question of scientific man-power in the United States of America, the setting up of a National Scientific Personnel Board and the establishment of a register of professionally qualified scientific workers are outlined. The Council of the Physical Society formally approved of these recommendations.

MOVEMENT OF SWIFTS IN SUMMER

THE year 1950 was a good one for studying the movements of swifts (*Apus apus*), and during the year the movements of forty thousand birds were recorded: a report on the observations has been made by H. G. Hurrell and recently described in *British Birds* (**44**, No. 5 ; May 1951).

Movements were found to take place not only during arrival and departure but also in the middle of the breeding season as well. The date when movement occurs is the main reason for classifying it as immigration, emigration or a movement occurring between the two. There is no certain way of distinguishing movements in the field, although there is a tendency for larger numbers of birds to group together when they are leaving Great Britain.

Swifts appear to penetrate the country from the south and work northwards. Arrivals over many years average a day or two earlier in the south than in the south-east. The east coast as a rule is reached rather late and usually in such small numbers that there is little to indicate any spring passage of swifts from the British Isles to other countries.

It is difficult to say when the arrival period ends because movements which have a migratory appearance may take place at any time while swifts are in Britain. Large movements occur in June and early July. These are thought to be undertaken because unfavourable weather forces the swift to seek regions with more adequate food supplies ; the food of the swift is adversely affected by the passage of a cyclone or depression.

In 1947 Koskimies suggested that the birds tried to avoid an advancing depression by flying against the wind round the south-east side of it, and that these weather movements are undertaken by first-year non-breeding swifts and, to a varying extent, by the breeding birds. If mid-season movements were always bad-weather movements, a comparison of the data with meteorological records should show some kind of broad correlation. At times this could be found ; but there are cases when there is no obvious connexion between major movements and low temperatures or low pressures. The 1950 mid-breeding season records took place at a time when weather conditions were comparatively stable and an anticyclone was maintaining fine warm weather over most of the British Isles. Nor is there clear evidence that the birds taking part in these weather movements are first-year non-breeding swifts. As yet the evidence is insufficient to say whether large mid-season movements are composed mainly of British swifts or of swifts which have just arrived from overseas.

It is impossible to say when emigration begins, since it commences during July when mid-season movements may still be taking place. Many breeding and most non-breeding swifts leave during July. During this month in 1950 swifts were frequently on the move, while August showed an almost complete absence of any swifts flying northwards ; the main directions were south or south-west. Early in August the British Isles are practically drained of breeding swifts. Yet quite large numbers were recorded throughout the month at favoured spots, especially on the east coast. During the last ten days of August, there was a widespread and, for the time of the year, remarkably strong wave. Such large numbers on these late dates are surprising, and it is suspected that these are largely swifts from other countries in more northerly latitudes visiting Britain on their return passage.

In another article in the same issue of *British Birds* ("The Use of Mobile Observers in the Study of Patterns of Migration"), Arnold Darlington criticizes much of the work on the migration of swifts which has been done in recent years because observations have been made at fixed vantage points, a method which has inherent in it several possible errors.

These errors are reduced if watchers deploy over an area and attempt to locate the main concentrations of swifts and to follow up any flight-lines radiating from them. The use of mobile squads of observers operating on bicycles has proved particularly useful, skilled riders being able to ride at a speed greater than the ground-speed of a migrant swift. In May 1950 the use of fifty-seven cyclists experienced in this mobile method of observation and operating in nineteen units enabled an intensive study to be made of the distribution of migrating swifts passing through south Cambridgeshire. From their results it would appear that, first, in anticyclonic, stable conditions, with light wind and mild temperatures, the movement of swifts tends to follow individual tracks and, although flight-lanes may be followed to some extent, they are not immediately apparent and may require careful seeking. The swifts tend, however, to be attracted by certain places, and here the flight-lanes may become concentrated and obvious, often persisting in their essential form for days on end. Second, in more unsettled conditions, with strong wind, low temperatures and cloud, the swifts may take to watercourses in great numbers, flying low and tending to 'pile up' in some places.

T. H. HAWKINS

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Ancient Greek Plated Coins

The techniques of the production of the officially issued plated coins of ancient Greece have been discussed at length by Campbell[1]. In the samples examined, it was inferred that the plating had normally been effected by a fusion process analogous to that by which Sheffield plate was later made. Examples are, however, reported in which a silver solder may have been employed, though the evidence is not sufficiently clear, in Campbell's view, to provide definite proof.

During the examination of a number of similar plated coins, one, however, a didrachm of Neapolis, B.M.C., p. 100/59, the date of which is approximately 300 B.C., was found in which it was certain that solder had been used. Between the core which, incidentally, consisted of copper 95·7 per cent, lead 0·7 per cent, zinc 0·4 per cent and silver 1·9 per cent, and the silver case, there existed a definite, and, on the surfaces, regular layer of a silver–copper alloy. At the edges of the specimen, however, as is shown in Fig. 1, two layers of this solder are to be seen. In Fig. 2 is shown the structure of this duplex layer at higher magnification. It consists, essentially, of a silver–copper alloy, which, from the structure, would appear to be approximately 60 per cent silver–40 per cent copper. It will also be noted from Fig. 2 that the eutectic structure which would be expected if it were due merely to interdiffusion of silver and copper at high temperature is almost non-existent, as a result presumably of previous spheroidization.

From these observations, coupled with the examination of the whole section of the coin, it is apparent that the plating operation was effected by first making a shallow silver cup to fit the copper core, lining this with a thin sheet of the silver solder, and, after the insertion of the core, covering the whole with another inverted cup, similarly lined with solder. When the whole was afterwards reheated above the temperature of the silver–copper eutectic, the solder would melt and run between the two cups, fusing core and plate together. A gentle hammering of the rim would complete the preparation of the blank, which, as the twinned structure of both core and plate

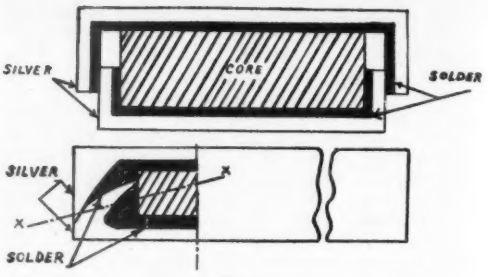

Fig. 4

shows, was then struck hot. This plating process is shown diagrammatically in Fig. 4. Fig. 1 would then represent a section such as that on *XX*. Such a method of production is in excellent agreement with that suggested by Prof. E. Darmstaedter[2].

For comparison, in Fig. 3 is shown the typical silver–copper eutectic obtained by direct fusion, in all ways similar to the corresponding structures observed by Campbell. This proof of a definite soldering operation at this early date seemed of sufficient interest to justify publication.

We are pleased to acknowledge financial assistance from Messrs. Imperial Chemical Industries, Ltd., in support of this and other work on the methods of production of ancient coins.

F. C. Thompson
A. K. Chatterjee

Department of Metallurgy,
University, Manchester 13. March 21.

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X-Ray Crystallographic Measurements on some Compounds showing Intramolecular Overcrowding

It has been recognized for some time that there exist classes of aromatic structures in which the (intramolecular) distance of closest approach between non-bonded atoms, calculated on the basis of conventional bond-lengths and bond-angles, is smaller than the sum of the van der Waals' radii of these atoms. Bell and Waring[1] have suggested the term

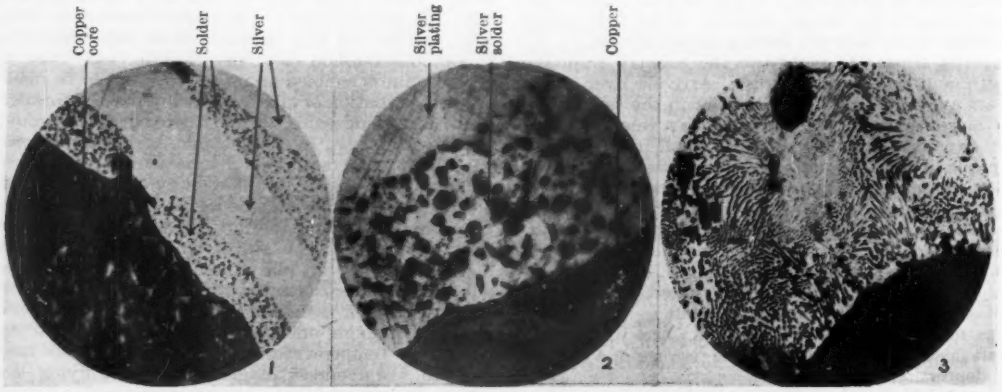


Fig. 1. Double film of solder on rim of coin. × 80. **Fig. 2.** Structure of solder. Light constituent is the silver-rich phase, the dark the copper-rich solid solution. × 440. **Fig. 3.** Typical silver–copper eutectic

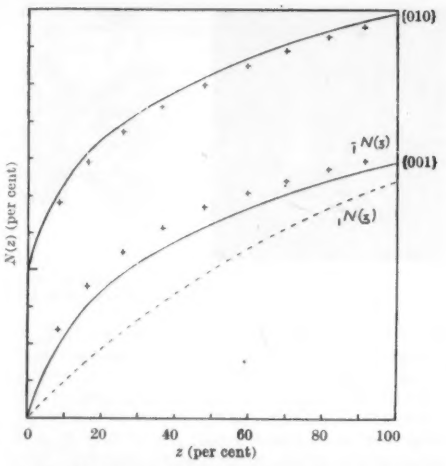
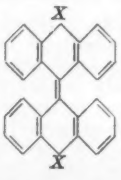


Fig. 1. Graphical comparison of functions $_{\bar{1}}N(z)$ and $_{1}N(z)$. Experimental points for the dixanthylene {001} and {010} zones. Successive curves displaced vertically by 40 per cent

'intramolecular overcrowding' for this type of steric effect.

We may assume that the strain due to such abnormal approach distances is relieved by distortion of the molecule: indeed, substituted 3 : 4-benzphenanthrenes[2] and 3 : 4 : 5 : 6-dibenzphenanthrenes[1] have been fully or partially resolved into optical isomers, and are not, therefore, planar molecules. Such departure from the regular structure of the aromatic ring system can be investigated by X-ray crystallographic methods; we have therefore surveyed a series of compounds, of which the most promising are listed in Table 1. We are now investigating tetrabenznaphthalene[3] and 3 : 4-benzphenanthrene[4] by two-dimensional Fourier methods; discussion of their 'abnormalities' must await completion of the structure analysis.



There exists a second class of overcrowded molecules of the accompanying general formula, such as dianthrone (X = CO) and dixanthylene (X = O), in which the steric effect depends on the presence of the central double bond (the corresponding dihydro compounds, such as 10 : 10′-dianthronyl, are free from overcrowding). These compounds are also of interest because of their thermochromic properties (for example, ref. 5), which have recently been investigated[6,7] spectroscopically; as a result of these studies, dianthrone has been assigned a configuration in which "the ground state is a singlet with the double bond in a state of considerable torsion"[6].

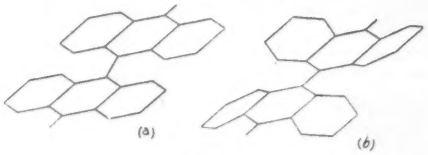


Fig. 2

Our preliminary results for dianthrone and dixanthylene are given in Table 2. Cell dimensions and space group of dianthrone unequivocally imply that the molecule has a centre of symmetry. In dixanthylene it is not possible to determine the space group unambiguously from the systematic absences alone; however, the Wilson test[8,9] applied to the intensity distribution in the $h0l$ and $hk0$ zones has shown both zones to be centric (see Fig. 1). We therefore assign to dixanthylene the space group $C2/c$. Packing considerations make it unlikely that the molecule has a twofold axis of symmetry. We conclude that dixanthylene, like dianthrone, is centrosymmetric.

We can envisage the following three extreme possibilities for their molecular shape: (i) fully planar; (ii) biplanar (Fig. 2*a*); (iii) bent (Fig. 2*b*). In both the biplanar and the bent forms the overcrowding is relieved. In order to decide between these possibilities, we are now investigating the crystal structure of dianthrone by two-dimensional Fourier methods.

If the molecular configuration of dianthrone in the crystalline state is retained in solution, the X-ray evidence conclusively rules out any configuration in which the two anthrone ring systems are twisted

Table 1

Compound	a	b	c	β	n	ρ exp.	ρ theor.	Space group
3 : 4-Benzphenanthrene	14·69	14·19	5·75	—	4	1·26	1·26	$P2_1\,2_1\,2_1$
Tetrabenznaphthalene	20·45	7·74	12·18	119° 33′	4	1·29	1·28	$P2_1/a$
3 : 4 : 5 : 6-Dibenzphenanthrene	17·46	14·24	5·83	94°	4	1·26	1·27	$P2_1/a$
1 : 4 : 5 : 8-Tetraphenyl naphthalene	17·1	22·0	5·93	—	4	1·25	1·26	$P2_1\,2_1\,2_1$

Table 2

Compound	Formula	a	b	c	β	n	ρ exp.	ρ theor.	Space group	Molecular symmetry
Dianthrone	$X \equiv C = O$	10·20	8·45	12·67	119° 48′	2	1·35	1·35	$P2_1/c$	$\bar{1}$
Dixanthylene	$X \equiv O$	14·87	12·90	9·41	95°	4	1·33	1·31	$C2/c$	$\bar{1}$ or 2

Table 3

Configuration	Free rotation about central bond	Possible stereo-isomeric forms
Planar (i)	No	*Cis* and *trans* isomers
Biplane (ii)	No	*Cis* and *trans* isomers
or		*Cis* should be resolvable into two optical isomers
Bent (iii)	Yes	Two optical isomers

relative to one another about the central bond, as suggested by Grubb and Kistiakowsky; furthermore, as can be seen from Table 3, resolution of disubstituted dianthrones into optical isomers will not necessarily be sufficient to decide the exact molecular shape of this type of compound.

We wish to thank Drs. L. Haskelberg and J. Szmuszkowicz for samples of 1 : 4 : 5 : 8-tetraphenyl naphthalene and 3 : 4 : 5 : 6-dibenzphenanthrene respectively, both of which were prepared by new syntheses. Full details of this work will appear elsewhere.

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Department of X-Ray Crystallography,
Weizmann Institute of Science,
Rehovoth, Israel. March 4.

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Fourier Synthesis by Optical Interference

The expression of the electron density in a crystal as a Fourier series is the mathematical equivalent of the process of image formation by light waves in an optical instrument. Thus, if the X-ray diffraction data can be converted into appropriate light waves, it should be possible to produce an image of a crystal optically instead of by the more arduous process of calculation. Making use of this idea, Bragg[1] produced an image of the projection of the crystal diopside, $CaMg(SiO_3)_2$, on the (010) plane.

This crystal, however, provides only a special case, in that no phase differences exist between the scattered waves. Buerger[2] has solved the problem of introducing phase differences by the use of mica plates, tilted to produce the required retardation. Marcasite, FeS_2, the crystal to which he has applied the method, is centrosymmetrical, and so the phase differences in the scattered beams are either 0 or π; thus mica plates need be placed only in certain of the interfering beams, and only a fixed tilt is required.

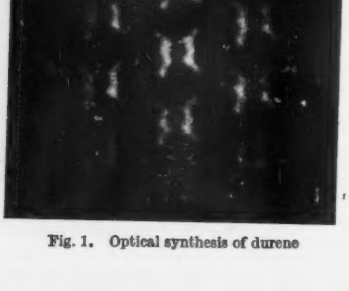

Fig. 1. Optical synthesis of durene

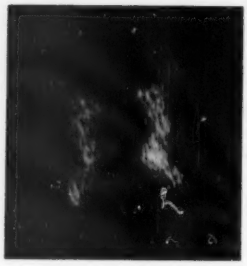

Fig. 2(*a*) One molecule from Fig. 1 enlarged
Fig. 2(*b*). Electron density map for comparison with Fig. 2(*a*)

We have made use of another method which, although it can be used only for centrosymmetrical crystals, appears to us to be simpler and more easily adaptable to experimentation. An opaque plate is drilled with equal holes at the points of the reciprocal-lattice section of the crystal; in each hole is placed a small tube fitted with a disk punched from an optically uniform sheet of mica, and the whole is viewed through crossed nicols. Each mica plate transmits an intensity of light depending upon its orientation, and thus each may be turned to transmit an intensity proportional to the intensity of the corresponding X-ray reflexion. It may easily be shown that the amplitude of the transmitted light is proportional to $\sin 2\varphi$, where φ is the angular displacement of a disk from one of its extinction positions; thus, on passing through $\varphi = 0$ the amplitude changes sign, and in this way phase changes of π can be simulated.

We have applied the method to the data given by Robertson[3] for durene, and the result, together with the calculated electron-density map for comparison, is shown in Figs. 1 and 2. Although the representation is not perfect, the molecule is quite recognizable, and the method would certainly serve to distinguish between possible and impossible combinations of signs.

A more complete account of the method, together with plans for obtaining a clearer image, and for making use of it in crystal-structure determination, will be published elsewhere.

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May 1.

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[2] Buerger, M. J., *J. App. Phys.*, **21**, 909 (1950).
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Cold Emission of Electrons in Spark Gaps

Studies[1,2] of sparks in short gaps have shown that under suitable conditions breakdown can occur within times, after the application of the gap voltage, which are considerably smaller than those expected if the initial ionization in the gap were due only to natural processes such as natural radioactivity, cosmic rays, or the break-up of gaseous ions. It is clear, therefore, that there must be another source of initiatory electrons. There is, however, considerable doubt concerning the nature of these sources, and the mechanism of electron liberation from them.

Pre-breakdown electron production in a spark gap is related to the time-lag of sparking, and considerable information on electron production can be obtained from analysis of time-lag data; under certain conditions, the inverse of the statistical lag is a measure of the rate of electron emission from the cathode under the given gap conditions. In this way, the rates of electron emission from cold nickel and tungsten electrodes, in short parallel-plate gaps in the atmosphere, under the influence of spark overvoltages up to 200 per cent, have been investigated in this laboratory, using a technique which permitted the effect of a single initial electron to be recorded. The spark current was suitably limited so that effects such as electrode erosion were negligible. The investigation showed that the surface condition and previous treatment of the cathode exerted great influence on the rate of pre-breakdown electron emission. A most significant result was that enhanced cold emission occurred when the average electric field F ($= V/d$) in the gap was of the order of 10^5 volts/cm., and it is not easy to see how electron emission of the magnitudes observed could be field emission from a metal, as it is well known that such emission requires fields of 10^7 volts/cm. or more.

In order to investigate this problem, the rate of electron emission i from the cathode was measured for various values of gap voltage V, and a relationship between i and V was found. For a cathode of nickel, oxidized by previous sparking in air, considerable electron emission of the order of 10^4 electrons per second was found for values of the macroscopic electric field in the gap of the order of 10^5 volts/cm. The relationship between i and V experimentally established was:

$$\ln(r) = -A/V + B, \qquad (1)$$

where $r = id^2/V^2$.

The following interpretation of this equation indicates that the mechanism of emission of these initiatory electrons was a field process.

The Fowler–Nordheim[3] field emission equation can be written:

$$\ln(i/F^2) = -(6{\cdot}8 \times 10^7\, \varphi^{3/2})/F + \ln(CS),$$

where S is the area of the emitting surface, and $C = 38{\cdot}8 \times 10^{12}\, (\mu)^{1/2}/(\mu + \varphi)\, \varphi^{1/2}$, in which φ is the work function of the surface, and μ is the parameter of metallic electron distribution in the Fermi–Dirac statistics.

This equation can be written:

$$\ln(r) = -(6{\cdot}8 \times 10^7\, \varphi^{3/2}\, d)/V + \ln(CS). \qquad (2)$$

Thus, equations (1) and (2) are the same when $A = 6{\cdot}8 \times 10^7\, \varphi^{3/2}\, d$, giving the same slope in the $\ln(r)$, $1/V$ curves; and $B = \ln(CS)$, giving the same intercept on the $\ln(r)$ axis.

Thus, the experimental equation (1) leads to estimates of φ, the work function of the source from which the electrons were extracted, and also of S the area of the emitting surface. Values thus obtained are $\varphi = 0{\cdot}1$ volt, and $S \sim 10^{-14}$ cm.^{2}.

If the value of $\varphi \sim 4{\cdot}5$ volts for common metals is used in equation (1), then to obtain the measured emission of 10^4 electrons per second, F must be of the order of 10^7 volts/cm.

In this work, F, given by V/d, is of the order of 10^5 volts/cm. Consequently, we have alternative conclusions to draw; either F in these experiments at the surface of the electrodes is some hundreds of times greater than the macroscopic applied field, and the electrons are released from the pure metal, or φ, the effective work function of the surface layer, is much less than 4·5 volts, and the electrons are released from that surface.

Schottky[4] has estimated a maximum value of about 10 for the intensification of the local field at microscopic points on the electrode surface, and substitution of this value in equation (1) gives $\varphi = 0{\cdot}48$ volt.

On this view, then, the electrons could not have come from a pure metal, still less from a metal with an electronegative monomolecular oxide surface film with a still higher effective work function. The most reasonable suggestion is that the electrons come from the surface oxide layer itself, and these estimated values of φ and of the emitting area of approximately molecular cross-section suggest oxygen ions as the source. These results, therefore, support the view that the cathode oxide layer, always present on electrode surfaces in air, is the source of electrons, extracted by field emission, which can initiate impulse sparks.

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Ultra-Violet Absorption Spectra of Gallium and Indium Monofluorides

Recent work on equilibria involving aluminium monohalides[1] suggested that gaseous gallium and indium monofluorides might be formed by reaction of the metals with aluminium trifluoride. This has proved to be so, and we have been able to photograph the absorption spectrum of gallium fluoride at about 1,000° C., and that of indium fluoride at about 1,400° C.

Vibrational analyses of the three band systems for each molecule expected by analogy with the other halides[2] have been completed. The constants derived are given in the accompanying table.

State			ν_e	ω_e	$x_e\omega_e$	$y_e\omega_e$
GaF	C	$^1\Pi$	47364·$_6$	541·$_0$	8·$_9$	−0·6
	B	$^3\Pi_1$	33427·$_7$	666·$_4$	4·$_9$	—
	A	$^3\Pi_0$	33098	659·$_4$	4·$_9$	—
	X	$^1\Sigma^+$	0	623·$_2$	3·$_4$	—
InF	C	$^1\Pi$	42808·$_2$	463·$_8$	7·4_2	−0·4_6
	B	$^3\Pi_1$	31257·$_7$	572·$_6$	3·4_3	—
	A	$^3\Pi_0$	30442	571·$_2$	3·4_3	—
	X	$^1\Sigma^+$	0	534·$_7$	2·5_6	—

The assignment of states A and B as $^3\Pi_0$ and $^3\Pi_1$ respectively is supported by the fact that the bands of the systems A—X are single-headed, whereas those in B—X possess two heads. The $^1\Pi$ states converge rapidly to give dissociation limits at about 6·3 eV. for gallium fluoride and 5·7 eV. for indium fluoride. A more detailed account of these systems will be published later.

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Theoretical Determination of Electron Density in Organic Molecules

In a recent paper, Abrahams, Robertson and White[1] have determined the electron density in naphthalene by means of X-ray analysis. They found that the electron density is greatest at the carbon atom in the meso-position, smallest at the β-position, and intermediate at the α-position. Between each pair of carbon atoms there is an electron density, evidently due to the binding pairs, which assumes its largest value between the α- and β-positions, and the smallest value between the two meso-positions.

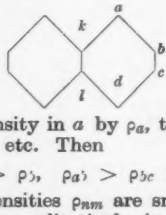
It may be of interest to note that precisely these results can be derived, at least qualitatively, from the theory of the chemical bond. I have used the method first applied by Heitler and Rumer[2] for determining the wave function of naphthalene in the zeroth approximation. Starting from a set of independent pure valence states, the energy can be calculated in terms of the well-known exchange integrals (by solving the corresponding secular equation), and hence the corresponding linear combination of pure valence states can be obtained.

Knowing the wave function, the calculation of the electron density is straightforward and follows the same pattern as that of the energy. If u_a, u_b are the wave functions of the valence electron in the atoms a and b, then the electron density depends on two types of integral:

$$\int |u_a(1)|^2 d\tau, \qquad \int u_a^*(1)\, u_b^*(2)\, u_a(2)\, u_b(1)\, d\tau. \quad (1)$$

Each occurs with certain algebraic coefficients arising from the solution of the secular problem. The first integral in (1) gives rise to an electron density at a, the second also to an *exchange density* between a and b. Values for these integrals can be estimated from the analogy of the hydrogen molecule, but the qualitative results depend on the valence structure of the molecule alone.

Carrying out this analysis, and taking into account only the interaction between neighbouring atoms, the following results are found. We denote the atoms in naphthalene as in the accompanying formula,



the electron density in a by ρ_a, the density between a and b by ρ_{ab}, etc. Then

$$\rho_k > \rho_a > \rho_b, \quad \rho_{ab} > \rho_{bc} > \rho_{ak} > \rho_{kl}.$$

All exchange densities ρ_{nm} are smaller than the ρ_n. The results are qualitatively in perfect agreement with the above experiments.

Attempts in a similar direction have been made by Daudel and Pullman[3]; but their results are not quite consistent because they depend on the choice of the independent basis of valence diagrams. This is not the case in our method.

Details will be published in the *Helvetica Chimica Acta*. I wish to thank Prof. W. Heitler for his advice and guidance, and the Stiftung für Stipendien auf dem Gebiete der Chemie for a grant.

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Ferromagnetic Resonance Absorption and a New Transition in $NiOFe_2O_3$ at Low Temperature

Microwave absorption phenomena, similar to those reported by Bickford for magnetite[1], have been observed for nickel ferrite in measurements at a wave-length of 3·2 cm. made from room temperature down to − 195° C. At the lowest temperatures, two absorption peaks were obtained at 1,490 Oe. and 200 Oe., the latter gradually decreasing with rising temperature and finally disappearing at about − 120° C. The value of g and the maximum absorption increase with decreasing temperature. An anomaly in the magnetization, similar to that found by Weiss and Forrer for magnetite[2], was observed in the range − 120° to − 195° C., where the magnetization falls suddenly by an amount which is the smaller, the higher the field. Similarly, the electrical resistivity rises suddenly in the same range. These phenomena may be due to a transition between − 120° and − 195° C.

Experiments at temperatures below − 195° C. are being planned.

I wish to express my thanks to Dr. T. Muto of the University of Tokyo for his valuable suggestions, and also to Mrs. Y. Torizuka, J. Simoizaka, Y. Kojima and Miss K. Takahasi for their assistance during the course of the experiments. Detailed results of the present work will be published in *Sci. Rep. RITU*.

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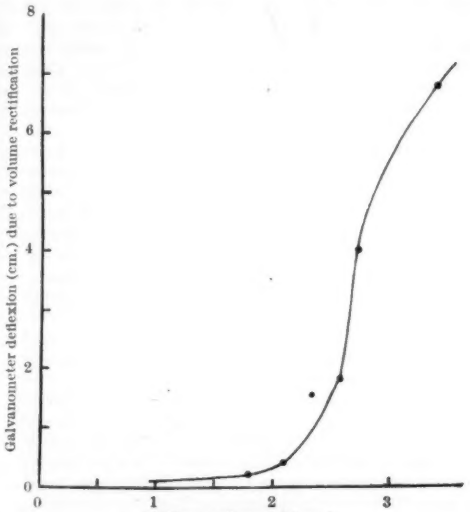
Volume Rectification in Zincite

The experiments of Khastgir and Das Gupta[1] showed that when carborundum, zincite or silicon was placed between two mercury electrodes giving large contact areas, there was considerable rectification, while similar experiments with symmetrical crystals like iron pyrites, magnetite, galena, etc., showed no rectification when the surface effects were eliminated. These experimental results suggested that the rectification observed in polar crystals such as carborundum, zincite or silicon with electrodes of large contact-areas should be associated with the asymmetry in the structure of these crystals. The experiments of Deaglio[2] with two different thicknesses of carborundum having the same contact-areas on the opposite faces, mechanically scraped plane and platinized, showed that rectification per centimetre thickness, as indicated by the static characteristic curves, was the same. This proved that the observed rectification in carborundum was definitely associated with the volume of the crystal and not with the area in contact with the electrodes. The object of the present communication is to report some experimental results with zincite, which has shown similar rectification depending on the volume of the crystal. A theoretical treatment is also given of the origin of volume rectification in polar crystals.

The zincite crystal cut in the form of a cube was mounted between two plane electrodes of large contact area pressed tightly against the opposite faces. Having applied a constant radio-frequency voltage

from a tuned circuit to the electrodes, the rectified current was measured by a suitably shunted mirror galvanometer for various thicknesses of the same crystal, keeping the resistance of the circuit constant. The two opposite faces of the same area were carefully scraped to reduce the thickness and, after mounting the crystal, the total resistance of the crystal circuit was made the same by inserting additional resistance to make up for each reduced thickness. The observed rectified current in the crystal circuit was found to decrease with the decrease of thickness for the same input radio-frequency voltage. The experimental results for a frequency in the neighbourhood of 1 Mc./s. are shown in the accompanying graph.



Curve for zincite, 0·945 Mc./s.

In explaining the experimental results, we shall assume that the specific resistance of a polar crystal for the two opposite directions has different values, ρ_1 and ρ_2. If t be the thickness and A the area of the crystal in contact with either electrode, then the rectified current is :

$$i_r = V\left[\frac{1}{r_1} - \frac{1}{r_1 + (\rho_2 - \rho_1)\,t/A}\right], \qquad (1)$$

where r_1 is resistance of the crystal circuit in one direction, V the applied voltage and ρ_2 is assumed to be greater than ρ_1. Putting $m = (\rho_2 - \rho_1)/r_1.A$, we get :

$$i_r = \frac{V}{r_1} \cdot \frac{mt}{1 + mt}. \qquad (2)$$

Introducing now the 'electro-resistive' effect of Osterberg[3] in crystals like carborundum and zincite which have no centres of symmetry, the resistance of such a polar crystal, under isothermal conditions, along any direction, can be expressed as a function of the applied voltage, as follows :

$$r = a + bV + cV^2, \qquad (3)$$

where a, b, c are electro-resistive constants. The difference in resistance for currents flowing in the two opposite directions is then given by

$$r_2 - r_1 = (\rho_2 - \rho_1)\,t/A = 2b.V;$$

so that

$$V = m.r_1.t/2b. \qquad (4)$$

Substituting this expression for V in (2), we get

$$i_r = \beta.t^2/(1 + mt), \qquad (5)$$

where

$$\beta = m^2/2b.$$

For carborundum and zincite crystals, either of which has a very high resistance, $m \ll 1$, and we should expect a square-law variation of rectified current with thickness, when the total resistance of the crystal circuit is kept constant. From our experimental results with zincite, it appears that Osterberg's 'electro-resistive' effect, which is the basis of formula (5), is the main cause of volume rectification observed in such a polar crystal.

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Crustal Layers of the Earth

In a discussion on the granitic layer of the earth's crust[1] Dr. P. L. Willmore criticized the P^* data from near earthquakes and is reported to have remarked that, "In South Africa, a similar tendency for waves to arrive early at distances beyond 120 km. is associated with the exposure of high-velocity rock in the region where the onsets are observed". This brief statement with regard to the South African observations may be misleading.

In a seismic study of the crustal layers in the western Transvaal[2], it was found that between 220 and 300 km. there was a large and well-defined phase which was rather more than 1 second early with respect to the P_1 line ($V_1 = 6{\cdot}09$ km./sec.). It was pointed out that the early onsets could be explained in three ways : (1) on the basis of a single-layer crust with a thin surface covering of high-velocity material in the neighbourhood of the field stations ; (2) on the basis of a single-layer crust in which the velocity increases with depth ; (3) on the basis of an intermediate layer.

If (1) be the correct explanation, then either (*a*) the phase travelled in the faster medium for its *entire* path after leaving the Witwatersrand system, or (*b*) it must have entered the surface layer of higher velocity from the lower-velocity material. In case (*a*), the travel-time graph should have been a straight line with a slope corresponding to the higher velocity. In (*b*), it is well known that it is only with exceptional dispositions of a high-velocity over a low-velocity medium that a phase with relatively large amplitudes would be observed. The geological maps of the area do not suggest that such dispositions of the media exist in the area in question.

Correspondingly early S arrivals were not observed. This fact, far from weakening the case for a change in the composition of the crustal layers at depth, serves to strengthen it. Assuming a single-layer crust with P and S velocities of $V_1 = 6{\cdot}09$ km./sec. and

$v_1 = 3{\cdot}68$ km./sec., the thicknesses of the crustal layer as calculated from the P and S observations are $34{\cdot}2 \pm 0{\cdot}8$ and $38{\cdot}2 \pm 1{\cdot}0$ km. respectively. The inference to be drawn from the smaller thickness found for the P phases is that the ratio of the average velocities of P and S waves in the crust is greater than the ratio V_1/v_1. This is consistent with the fact that early P arrivals were observed between 220 and 300 km., whereas early S arrivals could not be identified with certainty.

Finally, there is a third argument. Given the thicknesses and velocities in the layers, it is possible to calculate the distances at which the P and S phases totally reflected at the Mohorovicic Discontinuity should appear. For the single-layer crust, these distances are 72 and 87 km. for P and S respectively. For the two-layer crust the corresponding figures are 92·9 and 99·5 km. respectively. The observations agree satisfactorily with the predictions for the two-layer crust.

Any one of the above arguments taken by itself might not be regarded as convincing; but when they are considered together it would seem reasonable to conclude from the South African observations that there is a change in the composition of the crustal layers at depth, and that the change is such that the ratio of the P and S velocities increases at depth. It is not possible to decide between a continuous variation of composition and a discontinuous change, that is, the existence of an intermediate layer.

It is of interest to examine the implications of this change in the ratio of the velocities. Birch and Bancroft[3] noted that "Quartz is peculiar in possessing high rigidity with respect to its bulk modulus". It follows that for rocks containing a fair proportion of quartz it would be expected that the ratio of the P and S velocities would be low. This tendency is strikingly illustrated by the data given in the accompanying table.

Velocities of Certain Rocks at 4,000 km./cm.² and 30° C.

Rock	Percentage of quartz	V_P (km./sec.)	V_S (km./sec.)	$\frac{V_P}{V_S}$
Sandstone (quartzitic)	80	6·08	4·00	1·52
Granite, Quincy	26	6·08	3·61	1·68
Granite, Rockport	28	6·24	3·59	1·74
Syenite, Ontario	0	6·05	3·36	1·80
Norite, Sudbury	8	6·49	3·65	1·78
Diabase, Vinal Raven	0	6·97	3·88	1·80
Diabase, Maryland	0	6·96	3·83	1·82
Gabbro, Mellen	0	6·96	3·71	1·88
Gabbro, French Creek	0	7·15	3·98	1·80

(The table was compiled from Table 5–8, p. 80, of the "Handbook of Physical Constants", Special Paper 36 of the Geological Society of America, and papers by Birch and his associates.)

Thus the seismic observations in South Africa are consistent with the view that the crustal layers increase in basicity with depth.

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Much of the evidence produced by Prof. A. L. Hales is directed against the postulate of uniformity for the materials above the Mohorovicic Discontinuity. The conclusions are indisputable up to that point, and the only question is the extent to which different types of rock are collected into horizontal strata extending over continental distances.

The observations can be explained on the assumption that two materials exist in the crust, propagating P waves with velocities of about 6·09 and 6·8 km./sec. respectively. The reflexions from the Mohorovicic Discontinuity show that substantial volumes of the high-velocity material must exist within 100 km. of the origin, whereas the fast refracted wave is observed between 220 and 300 km. At the shorter distances, the high-velocity material must be deeply buried; but there is no direct seismological evidence concerning the depth of the material which produces the refracted wave. The discrepancy between the estimates for the thickness of a single upper layer confirms the heterogeneity of the crust without yielding any further evidence on the distribution of the materials.

Seismologists often postulate horizontal stratification because they feel that such a distribution is inherently plausible, when their data may be equally consistent with other structures. The Transvaal seismograms show only that appropriate materials exist at an appropriate depth in one location, and at undetermined depths elsewhere. In some areas such evidence might be sufficient; but in the Transvaal the more distant recording stations were resting on the diabasic lavas of the Ventersdorp series, the properties of which are very similar to those required for the high-velocity material. Hence, the advocates of a high-velocity layer at depth have to admit three layers in the western Transvaal, but they dismiss the uppermost one as being too thin to transmit waves of measurable amplitude. In fact, the thickness of the lavas is known to exceed 5,000 ft. in some areas[1]; but I have not seen any figures relating to the thickness under the seismic stations. The difficulty of getting seismic energy into the surface layer does not appear to be overwhelming. The matter could be decided if observations along other profiles were available or possibly by a more exhaustive examination of existing data. In the meantime, it seems premature to assert that horizontal stratification provides the only possible explanation of the results.

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Reaction of Metmyoglobin with Hydrogen Peroxide

The formation of a well-defined red complex between hydrogen peroxide and methæmoglobin or metmyoglobin is well established[1–3]. Keilin and Hartree found that the formation requires one molecule of peroxide per hæmatin iron atom. With reducing agents this complex is reduced back to methæmoglobin or metmyoglobin, and in the overall reaction the peroxide is *reduced* to water.

In this respect the complex is very different from that formed between ionic ferric iron and hydrogen peroxide, which Evans, George and Uri[4] showed to have the ion-pair structure

$$[Fe.^{3+}.O_2H^-], \text{ that is, } Fe.O_2H^{2+}.$$

In a kinetic investigation of this system, Barb, Baxendale, George and Hargrave[5] found evidence that this complex plays no independent kinetic part,

and that peroxide decomposition is initiated by electron transfer as follows:

$$Fe^{3+} + O_2H^- \rightarrow Fe^{2+} + HO_2, \quad (1)$$

which results in the partial *oxidation* of the peroxide by the ferric ion. This difference in the fate of the peroxide in the two systems prompted our present investigation using recrystallized horse metmyoglobin, the preliminary results of which are outlined below.

The formation of a metmyoglobin – peroxide complex was observed at all hydrogen ion concentrations between *p*H 5·5 and 12·0. However, the reaction is only straightforward in the *p*H range 8–9, where maximum formation of the complex is obtained and complete regeneration of the metmyoglobin can be effected by adding mild reducing agents. The spectrum of the complex in this region shows a sharp band at 549 mμ with $\varepsilon_{m\mu M} = 9{\cdot}8$ and a broad band appearing as a shoulder at 570–585 mμ with $\varepsilon_{mM} = 8{\cdot}4$. In the Soret region there is a sharp band at 423 mμ with $\varepsilon_{mM} = 107$. With solutions of *p*H < 8 some complex is formed, but an additional reaction involving the hæmatin also occurs and full recovery of the metmyoglobin is not observed. When the reaction is carried out in solutions of increasing alkalinity above *p*H 9·0, progressively less complex is formed and a hæmatin degradation product, colourless both in the visible and Soret regions of the spectrum, is produced.

Table 1. Ferrocyanide Reduction of the Complex at *p*H 8·0

Initial complex $\times 10^5$ *M*	Ferrocyanide $\times 10^5$ *M*	Observed complex left $\times 10^5$ *M*	Complex reduced $\times 10^5$ *M*	Ratio: $\frac{Fe(CN)_6^{4-}}{\text{complex}}$
2·4	1·0	1·4	1·0	1·00
2·4	1·5	1·0	1·4	1·07
2·4	2·4	0·1	2·3	1·04
4·0	3·0	0·9	3·1	0·97

In addition to ascorbic acid, hydroquinone, and *p*-phenylene diamine, the complex was found to oxidize cysteine, *l*-malachite green, iodide ion (but not bromide ion) and ferrocyanide ion. This last reducing agent proved satisfactory in spectrophotometric titrations for estimating the oxidizing equivalent of the complex. These were done in the optimum *p*H range. Typical results are given in Table 1, which shows that when ferrocyanide is added to the complex, one ferrocyanide ion reacts per molecule of the complex. The complex thus has only one oxidizing equivalent compared with the two oxidizing equivalents of the peroxide itself. On the other hand, when varying amounts of ferrocyanide and metmyoglobin are mixed and peroxide is added, the full oxidizing capacity of the peroxide appears, as shown in Table 2. This suggests very strongly that the formation of the complex occurs as follows:

$$\underset{\text{(2 oxid. equiv.)}}{\text{MetMb} + H_2O_2} \rightarrow \underset{\text{(1 oxid. equiv.)}}{\text{Complex}} + \underset{\text{(1 oxid. equiv.)}}{X} \quad (2)$$

and that a transient oxidizing entity is produced which can react with added reducing agents if present initially, but which disappears if the complex formation is allowed to proceed independently.

These results indicate that the complex cannot be of the ion-pair type MetMb$^+$—OOH$^-$, for such a compound would have two oxidizing equivalents.

A tentative mechanism which can account for these results is the formation of an OH radical and 'ferrylmyoglobin' in a reaction of the type:

$$\underset{\text{(complex)}}{Fe^+(H_2O)} + H_2O_2 \rightarrow \underset{\text{(complex)}}{FeO} + \underset{(X)}{OH} + H_2O + H^+, \quad (3)$$

Table 2. Peroxide Added to Mixtures of Metmyoglobin and Ferrocyanide at *p*H 8·0

(Initial metmyoglobin and peroxide concentrations $1{\cdot}04 \times 10^{-4}$ *M* and $1{\cdot}01 \times 10^{-4}$ *M* respectively)

$Fe(CN)_6^{4-}$ $\times 10^5$ *M*	Complex formed $\times 10^5$ *M*	*Oxidizing equivalents of peroxide accounted for, $\times 10^5$
0	9·1	9·1
12	7·2	19·2
14	5·6	19·6
16	3·8	19·8
		Equivalents present initially, 20·2

* On the basis 1 mol. complex ≡ 1 mol. $FeCN_6^{4-}$ ≡ 1 equiv. H_2O_2.

where Fe^+ represents the hæmatin iron atom of metmyoglobin. Ferrylmyoglobin would be a compound of quadrivalent iron, analogous to the ferryl ion and the vanadyl ion, and thus have one oxidizing equivalent when reduced to a ferric compound. The observation by Keilin and Hartree[3] that with excess peroxide the complex is converted into oxymyoglobin could be explained by the further reaction of ferrylmyoglobin:

$$\underset{\text{(complex)}}{FeO} + H_2O_2 \rightarrow \underset{\text{(oxymyoglobin)}}{FeO_2} + H_2O. \quad (4)$$

This tentative mechanism may also be applicable to some of the complicated reactions of the peroxide complexes of the enzymes peroxidase and catalase. With peroxidase the green complex formed initially from equal amounts of enzyme and peroxide[6] may have the ion-pair structure and break up as in reaction 3, giving the second complex, pale red in colour. This complex with excess peroxide gives a third complex[7], deep red in colour, which according to reaction 4 would have an oxymyoglobin type of structure. Spectroscopic similarities, however, between this third complex (not the second complex) and the metmyoglobin complex may mean that the enzyme system is different.

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Monolayers of Synthetic Protein Analogues

Since the natural proteins consist of various amino-acids and their structures are very complex, it is desirable, in order to elucidate their structures and their physical and chemical behaviours, to synthesize simple protein analogues having any particular characteristics of protein molecules[1]. As part of this object, we have synthesized several polypeptides having normal aliphatic side-chains with various numbers of carbon atoms and studied the surface films of these polypeptides spread on water. These polypeptides were easily synthesized from the corresponding normal fatty acids by the N-carboxy-amino-acid anhydride method, and have molecular weights of about two hundred thousand. The effects of various solvents and catalysts on the course of

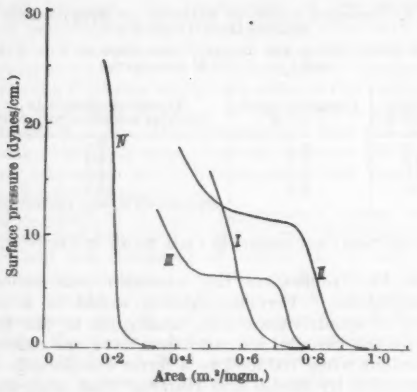

Fig. 1. I, Poly-DL-α-aminocaproic acid; II, poly-DL-α-aminocaprylic acid; III, poly-DL-α-aminolauric acid; IV, poly-γ-methyl L-glutamate

the polymerization of N-carboxyamino-acid anhydrides have already been reported elsewhere[2]. The surface film of poly-γ-methyl L-glutamate spread on water was also studied. The results obtained with surface films spread on water will be briefly described.

The polymers used in our present investigation are poly-DL-α-aminolauric acid, poly-DL-α-aminocaprylic acid, poly-DL-α-aminocaproic acid and poly-γ-methyl-L-glutamate. First, the force–area relations of these polypeptides were examined (Fig. 1). The curve for poly-DL-α-aminocaproic acid resembles very closely those given by ovalbumin and by pepsin film[3]. The limiting area of this curve is about 0·8 m.²/mgm. When the side-chains are longer, as in the cases of poly-DL-α-aminolauric and of poly-DL-α-aminocaprylic acid, a plateau, which is a region of very high compressibility, appeared in the force–area curves. When the area per amino-acid residue was plotted instead of the area per milligram polymer, the force–area relations were changed as indicated in Fig. 2; the longer the side-chains, the larger is the limiting area. Among the long and short side-chains found in the films of synthetic polypeptides, the longer ones contribute to the plateau appearing in the graphs. This is remarkably different from the steep inclination of curves resulting from shorter side-chains in films of natural proteins. The mean number

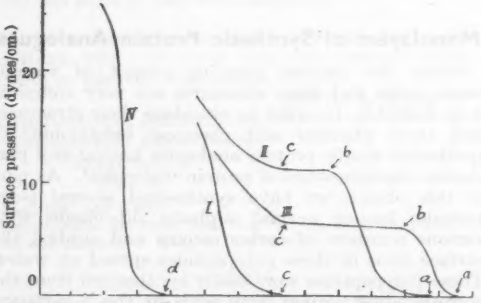

Fig. 2. For key to curves, see Fig. 1

of carbon atoms in the side-chains of natural proteins amounts to about three or less. It seems to us that the appearance of the plateau in the force–area curves is related to the length of the side-chains. No plateau was found in the force–area curves for poly-DL-α-aminocaproic acid and for poly-γ-methyl L-glutamate. These polymers have side-chains of four carbon atoms.

The shape and the limiting area of the force–area curves for poly-DL-α-aminocaprylic and poly-DL-α-aminolauric acid changed considerably with time elapsed after spreading the monolayer on the substrate before measurement; on the other hand, there was scarcely any change with monolayers of polymers with shorter side-chains.

For areas larger than that indicated by point *a* (Fig. 2), the polypeptide molecules were spread with chains flat on the surface. Between *a* and *b*, the surface pressure would be exerted mainly by the action of side-chains. From *b* towards *c*, the surface pressure remained practically constant. It suggests that the molecules of polypeptide are re-orientated in this region and the side-chains compressed away from the surface, so that they are forced upwards or downwards into the water. At point *c*, the area per residue is 14·7 A.². This corresponds to an area of —NH—CH—CO— residue in the closest packing of an arrangement of β keratin configuration. From *c*, the pressure was again increased by further compression. Thus, either the configuration of the backbone of the polypeptide had been changed from the β- to the α-type, or segments of the chain had left the surface. For the film of poly-DL-α-aminocaproic acid as well as that of ovalbumin, the re orientation of the molecules is easier than for the polypeptide films of the longer side chains, because of the shortness of the side-chains. This explains the absence of the plateau in the force–area curves for poly-DL-α-aminocaproic acid and proteins.

The limiting area per residue for the film of γ-methyl L-glutamate polymer is 7·5 A.². This is just half the area per residue of closely-packed chains of β-configuration. It is known that this polymer has a folded structure[4], and the copolymer of γ-methyl L-glutamate with phenylalanine has also the α_{II} configuration[5]. The latter polymer has the α_{II} structure even in a stretched state. This is in good agreement with our experimental results obtained by the surface-layer technique.

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A Colorimetric Method for the Determination of Sugars

VOLUMETRIC procedures have been used for the quantitative determination of sugars after separation by partition chromatography[1,2]. It has been our experience that these methods not only require considerable skill, but also they are lengthy and sensitive to slight variation of the conditions. We have therefore attempted to develop a simple quantitative colorimetric procedure. Preliminary experiments showed that the anthrone[3] and the α-naphthol sulphonate[4] reagents give good results with pure sugar solutions, but the presence of only traces of solvents such as butanol, phenol and propionic acid used in the chromatographic separation of the sugars rendered them useless.

It was then discovered that phenol itself in the presence of sulphuric acid provides a simple rapid method for the quantitative colorimetric determination of ketoses and aldoses and their methyl derivatives on a sub-micro scale. The method, applicable to all carbohydrates with either a free or potential reducing group, is particularly useful for determining sugars which have been separated by partition chromatography using phenol–water as the solvent. The orange-yellow colour, produced by adding sulphuric acid (5 ml.) to the sugar solution (2 ml.) containing phenol, is permanent; its optical density (measured at 490 mμ for hexoses and hexuronic acids and their derivatives and at 475 mμ for pentoses and their derivatives) when referred to a standard curve gives the concentration of the sugar.

This phenol–sulphuric acid reagent, which has enabled us to determine the composition of polysaccharides and their methyl derivatives on as little as 1 mgm. of material, thus offers an additional method for end-group analysis of polysaccharides[5]. The reaction is not limited to phenol, for certain amines such as N(1-naphthyl) ethylene diamine can replace phenol in the above reaction.

In conjunction with the above colorimetric method, it has been found convenient to extract the sugars from the strips of paper cut from the chromatogram by simply immersing them in water. Since the extraction is carried out at room temperature, there is no danger of decomposing the sugars[6]. Substances in filter paper which interfere with the sugar analysis can be largely removed by three or four 'chromatographic' washings with water; washing with dilute sodium hydroxide does not seem to improve the paper.

Further details of this work and its application to the determination of the structure of various polysaccharides will appear elsewhere.

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A New Paper Chromatography Solvent for Amino-Acids

PHENOL and collidine have remained the most widely used pair of solvents for two-dimensional paper chromatography of amino-acids since their introduction by Consden, Gordon and Martin[1]. The use of the latter solvent, however, is attended by certain disadvantages such as double spots and haloes[2], an offensive smell and possible toxic effects[3,4] and, in some countries, difficulty of supply. Alternative solvents have been suggested, for example, butanol – acetic acid[5], acetone – water[2] and pyridine – amyl alcohol[6]. Some defects of the latter system have recently been reported[7].

A new solvent giving an extremely wide distribution of R_F values is mesityl oxide, which has already been mentioned as a possible solvent for the paper partition chromatography of organic acids[8]. The difficulty encountered by Lugg and Overell[8], namely, the condensation of the solvent in the presence of formic acid, has been obviated by the use of re-distilled and fractionated solvent[9]. Because of the tendency to form peroxides on prolonged storage in contact with air, each batch of solvent should be tested for their presence before distillation. The fractionated solvent (b.p. 129–130°) alone does not give any movement of amino-acids; but the acid spots move when formic acid is added to the solvent system. The method of preparation of the most desirable mobile phase is to shake one volume of the solvent with one volume of formic acid (85 per cent) and two volumes of water. R_F values for the amino-acids in such a solvent are listed in the accompanying table, from which it can be seen that the spread of values is considerably higher than with collidine, and indeed almost as high as with phenol. An additional advantage with this solvent is its rapidity of migration, the solvent ascending about 50 cm. in twenty hours on Whatman No. 1 paper.

R_F VALUES OF AMINO-ACIDS

Amino-acid	R_F	Amino-acid	R_F
Alanine	0·35	Methionine	0·61
Arginine*	0·19	*nor*Valine	0·58
Aspartic acid	0·17	Ornithine†	0·08
Cystine	0·06	Phenylalanine	0·72
Glutamic acid	0·20	Proline	0·39
Glycine	0·22	Serine	0·20
Histidine	0·07	Threonine	0·26
*iso*Leucine	0·70	Tryptophane	0·81
Leucine	0·71	Tyrosine	0·63
Lysine	0·23	Valine	0·58

* Applied as monohydrochloride. † Applied as hydrobromide.

The tendency for mesityl oxide gradually to oxidize and polymerize on standing, with the formation of coloured substances, has been especially noticed in the acidified mobile phase, which after several days may develop a slight orange coloration. This difficulty has been avoided by making up small volumes of the mobile phase just prior to use and discarding any residual solvent after about two days. By this means an exceedingly high degree of reproducibility in R_F values has been obtained. Our usual practice is to allow the paper to become equilibrated thoroughly in the vapours of the stationary phase before introducing the mobile phase. The paper may be quickly and satisfactorily air-dried. Heating of the ninhydrin-sprayed sheet then brings up the spots in their characteristic colours. As with carboxylic acids, spots

obtained are discrete and should lend themselves well to quantitative studies[9]. All the chromatograms have been run as with other solvents, although it has been stated that prolonged breathing of the fumes should be avoided[10].

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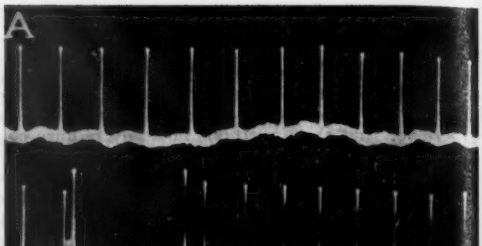
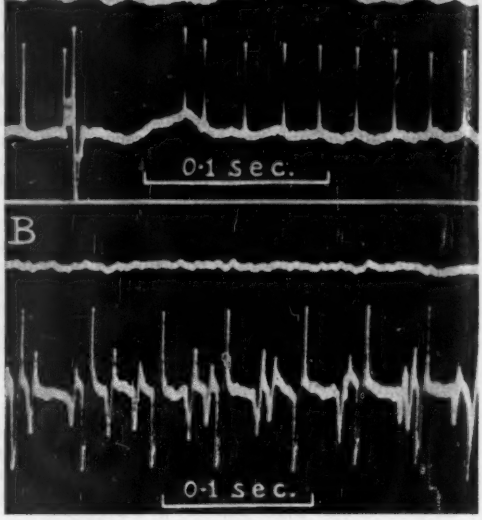
Afferent Limb of the Myotatic Reflex Arc

Within the past decade, the use of electronic methods has laid bare much of the mechanism underlying the myotatic, or stretch, reflex of mammalian striated muscle. Outstanding among these advances are Lloyd's demonstration of the monosynaptic nature of the myotatic reflex pathway, and his disclosure that fibres of large diameter (Group I fibres) constitute the afferent limb of this reflex arc[1]. However, the specific receptor organ responsible for initiating the stretch reflex has so far eluded positive identification, though the balance of evidence suggests muscle spindles rather than Golgi tendon organs[2].

Recently, Szentagothai[3] has brought forward histological evidence indicating that afferent fibres from spindles in the jaw-closing muscles enter the brain stem by way of the *m.o or* root, while those from Golgi tendon organs pass through the *sensory* root of the trigeminal nerve; furthermore, according to this author, the monosynaptic pathway for the masticatory muscles is completed by way of collaterals from the afferent fibres serving muscle spindles. These observations are difficult to reconcile with the conclusions of Rioch and Lambert[4], who state that the afferent pathway for the jaw-jerk lies in the sensory root of the trigeminal nerve. An attempt to resolve this apparent contradiction has therefore been made in a series of experiments on the trigeminal system in decerebrate cats, and the present communication summarizes the principal results of this investigation.

First, by means of a standard amplifier and oscillograph, an abundance of afferent impulses from stretch receptors in the jaw muscles has been recorded from the peripheral end of the severed motor root of the fifth cranial nerve. Fig. *A* (upper record) shows the discharge of one such ending when the masseter muscle is subjected to moderate stretch. The low mechanical threshold of these stretch endings, and the 'silent period' they exhibit during twitch of the muscle in which they lie (Fig. *A*, lower record), identify them as muscle spindle receptors[5]. This aspect of Szentagothai's findings thus receives oscillographic confirmation.





A. Decerebrate cat. Above: typical stretch receptor discharge elicited by moderate stretch of the masseter muscle and recorded from a fine filament dissected from the peripheral end of the severed motor root of the trigeminal nerve. Below: cessation of discharge from the same receptor during twitch of the masseter muscle. *B*. Decerebrate cat. Electrodes on the exposed lateral surface of the masseter muscle. Above: virtual absence of motor unit activity with the jaw supported in the closed position. Below: typical stretch reflex discharges of several motor units in the same muscle during moderate stretch of the latter after complete severance of the sensory root of the ipsilateral trigeminal nerve

Secondly, after severing the sensory root of the trigeminal nerve in other preparations, the motor root remaining intact, the stretch reflex in the masseter muscle was found to be as active as before (Fig. *B*, lower record). Both the afferent and efferent limbs of this reflex arc must therefore lie in the motor root, which, as Szentagothai has shown[3], carries afferent fibres from muscle spindles only.

The results of these experiments are, therefore, in full agreement with Szentagothai's histological findings, and can be regarded as providing direct physiological proof that muscle spindles and not Golgi tendon organs are the stretch-sensitive structures specifically concerned in eliciting the myotatic reflex. No certain explanation can be advanced for the contrary observations of Rioch and Lambert[4]; but it may be noted that, in two of the present experiments, the operation of cutting the sensory root apparently abolished the jaw-jerk. In view of the preservation of this reflex in the remaining experiments, despite complete (and, in some cases, bilateral) severance of the sensory root, it can only be concluded that such atypical results were brought about by unintentional damage, inflicted during the operation, to structures other than the sensory root. Although Szentagothai's studies[3], and the experiments described above, together establish that muscle spindles are indeed the receptor organs responsible for the stretch reflex, it has not yet proved possible to examine separately the reflex effects of impulses arising from

the two types of spindle ending[2]. However, in view of the large size of the afferent fibres terminating therein, it is reasonable to conclude that the *primary*, or annulospiral, endings are the actual receptors within the muscle spindles which form the starting point of the myotatic reflex arc.

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Inhibition of the Hypophysis of the Guinea Pig by Ultra-Sound Waves

Ultrasonic irradiation of the brain has been carried out both for diagnostic and for therapeutic purposes[1]. In the dog, neither electroencephalographic nor histological changes are elicited by ultrasonic irradiation, probably on account of the great absorption of the radiation mainly by the bones of the skull[2]. Since, as earlier observed[3], ultrasonic irradiation of the hypothalamus produced respiratory and circulatory changes, it was decided to examine the effects of irradiation of the pituitary gland. Guinea pigs were used for the experiments, partly because surgical hypophysectomy is almost impossible in this animal and therefore, in case of success, irradiation of the pituitary might prove an interesting and simple method of obtaining hypophysectomized guinea pigs.

Eleven animals, approximately fifteen days old, were grouped in five lots, the first consisting of three twin brothers, the other four comprising two twin brothers each. One of each group was kept as control while the other animals were exposed every other day to irradiation with ultrasonic waves, frequency 800 kc./s., intensity 10–40 watts, time 10 min. and radiant surface 2·5 cm.^{2}. Paraffin oil was employed as intermediary substance. The emitter was placed on the central part of the skull. As the radiation proceeded, the animals exposed to this irradiation showed defective growth compared with their controls, which doubled their weight in the same time.

The irradiated animals carried out movements with great difficulty and sometimes lost their equilibrium. Remarkable changes in the skin were also observed, such as ulcerations and loss of the hair, which looked short, frail and bristle. Radiographic examination (Fig. 1) revealed in the irradiated animals a general decalcification, a decrease of the bone trabeculæ, the vertebræ and all the bones in general being of reduced size. Ossification centres were small and badly ossified.

Examination of the adenohypophysis (Fig. 2) showed a noticeable congestion, with widened capillaries occupying a large proportion of the gland. The cells remaining between these vessels had only a little cytoplasm, frequently vacuolated; the large basophile cells were almost entirely absent; and there were abundant acidophile cells with pycnotic nuclei. This

(*a*) (*c*) (*b*)

Fig. 1. Radiographs of triplet guinea pigs after two months of ultrasonic treatment of the pituitary gland. Exposures: (*a*) 20 watts; (*b*) 40 watts; (*c*) control. Weights of these animals were: (*a*) 215 gm., (*b*) 200 gm., and (*c*) 350 gm. Lengths of the skeletons were (*a*) 16 cm.; (*b*) 14 cm.; (*c*) 21 cm.

nuclear disposition was remarkably frequent and could also be observed in some chromophobe cells and in many of the pars intermedia. In the thyroid a great number of follicles seemed inactive, of large size with a flat epithelium and a dense colloid substance, both scarcely retracted and vacuolated. The adrenal cortex showed somewhat retracted cells in its fascicular zone with homogeneous cytoplasm almost

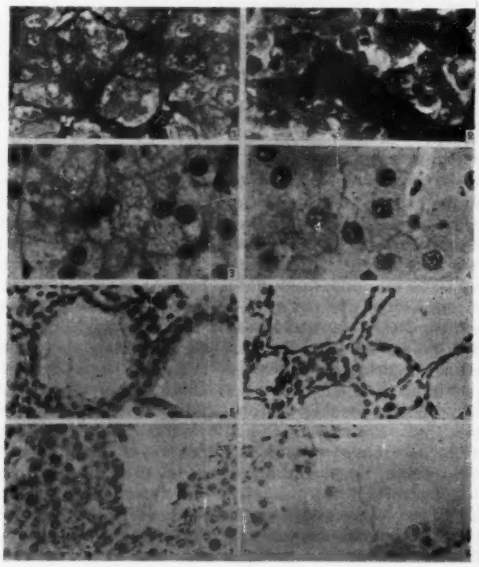

Fig. 2. 1, 3, 5, 7: adenohypophysis, adrenal cortex, thyroid and testis from normal animals. 2, 4, 6, 8: the same glands from irradiated animals

free of lipidic inclusions. The reticular zone of the gland was much congested; nearly every cell showed a pycnotic nucleus, and many were overcharged with pigmentary inclusions. In the testis, a number of seminiferous tubules were atrophied, and the cells of the spermatic series were arranged in only one or two rows. Cells in the condition following the primary spermatocyte had disappeared, with the consequent diminution of the number of mature spermatozoa. Many cells had pycnotic or lytic nuclei. The interstitial tissue was frankly atrophied.

Post-mortem examination of these animals revealed that all the viscera were atrophied, especially the glands, the weight and dimensions of which were much less than those of the controls. The pituitary gland and the fossa pituitaria were relatively small, and the testes were reduced to a third of the normal.

Irradiation of the hypophyseal zone with high doses of X-rays had no appreciable effect on guinea pigs during the growth period. Thus, a guinea pig of 200 gm. exposed to X-rays twice weekly during a fortnight (totalling 1,600 r.), grew to 410 gm. after 45 days. In the same period its unexposed twin brother, the initial weight of which was 230 gm., reached 420 gm. in the same period.

It may be concluded that ultrasonic irradiation constitutes an excellent and bloodless method of affecting the hypophysis of the guinea pig, so as to obtain animals with pituitary insufficiency. It may be possible to apply this method to bigger animals.

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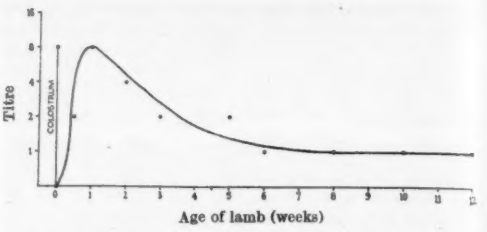
Absorption of Anti-Nematode Antibodies from Ewe's Colostrum by the New-born Lamb

During experimental work on helminth immunity, it was observed that the sera of month-old worm-free lambs gave positive reactions for anti-nematode antibodies. When this observation was made, all the available ewes but one had lambed. A small-scale test was made to determine whether antibodies to parasitic nematodes could be detected in the colostrum of nematode-infected ewes and whether their offspring acquired these antibodies as a result of suckling.

A colostrum sample was taken from a parturient ewe and serum samples were collected from the lamb at birth, that is, prior to suckling, three days later, and then at weekly or fortnightly intervals for three months. The lamb was allowed to run on pasture with its dam; but, though exposed to nematode infestation, eggs could not be detected in its fæces.

All sera and the colostrum were stored at — 20° C. until the end of the experiment. They were then titrated by means of the hæmolytic complement-fixation test. The antigen used was prepared from a mixed culture of *Cooperia curticei* and *Strongyloides papillosus*, following the technique described by Stewart[1].



The results (see graph) showed that the colostrum contained antibodies of relatively high titre. The serum of the new-born lamb did not contain any demonstrable antibodies until after suckling. The antibody titre reached a maximum at one week. During the next five weeks it decreased to a low level, which was maintained for at least three months.

These observations show that anti-nematode antibodies can be transmitted in a manner similar to the more commonly identified antibodies.

Whether the antibodies in the lamb's serum are related in any way to a resistance to nematode infestations has yet to be investigated.

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Changes in Electrical Conductivity during Bacterial Growth

Parallel measurements of the electrical conductivity and bacterial count in a solution containing glucose and peptone, in which a small amount of inoculum of *Bact. subtilis* has been introduced, show the typical lag, logarithmic and stationary phases, and have brought out the striking result that, even before the multiplication of bacteria takes place, there is an appreciable increase in conductivity. This result is to be attributed to the initial activity of bacteria through their multi-enzyme systems in splitting up the peptone in the medium into amino-acids, which are absorbed by the bacteria from the surrounding medium and provide the nutrient material for their growth. Chemical estimation of the amino-acids formed in the medium revealed a close parallelism between their concentration and the electrical conductivity of the suspension at various stages of bacterial growth. This investigation has thus clearly shown that amino-acid formation takes place through bacterial action in the medium before the bacteria begin to multiply.

The observation mentioned above provides evidence for the view that substances are passed from the cells into the medium during the lag phase, a view which is also supported by another observation of ours that the conductivity of a suspension of washed bacteria in 'conductivity water' increases exponentially with time for about six hours, although this increase is comparatively small, being about $0{\cdot}2 \times 10^{-12}$ mho per bacterium on the average.

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Apyrases of Moulds

THE mycelial mats of *Aspergillus niger* and *Penicillium chrysogenum* possess apyrase activity. The organisms were grown as surface cultures on synthetic media, and at regular intervals the mat was analysed for apyrase activity and for '7-minutes phosphate' in the acid-soluble fraction. During the first phase of metabolism, when sugar was being rapidly consumed, the enzymic activity and the content of labile phosphate were high. When autolysis set in there was a marked drop and sometimes even a complete disappearance of both apyrase activity and labile phosphate. Apyrase probably plays an important part in the metabolism of the mould.

Estimation of enzymic activity in culture solutions was rendered difficult because of the presence of orthophosphate; but at no time was the enzyme concentration high.

Considerable variation existed in the apyrase activity of different strains. The *p*H – activity relationship was different for *Aspergillus* and *Penicillium*.

Apyrase activity of the mycelium could be extracted by grinding with water in the Waring blendor. The apyrase of *Aspergillus niger* has been concentrated about 450-fold by fractionation with ammonium sulphate. A colourless solution was obtained which was free from glucose oxidase. The enzyme preparations were inhibited by both calcium and magnesium ions at a final concentration of $M/100$. This is in contrast to the marked stimulation of potato apyrase by added calcium ions[1]. Tests with inorganic pyrophosphate showed that the purified enzyme possessed powerful pyrophosphatase activity also. The relative speed of dephosphorylation of inorganic pyrophosphate and adenosinetriphosphate remained fairly constant without any sharp break during the various stages of purification of the enzyme.

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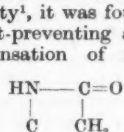
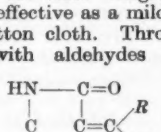
Mildew-preventing Activity of Rhodanine Derivatives

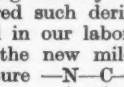
ALTHOUGH rhodanine (I) has some fungicidal activity[1], it was found to be ineffective as a mildew- or rot-preventing agent on cotton cloth. Through condensation of rhodanine with aldehydes and



I



II

ketones, derivatives (II) having marked mildew-proofing activity may be obtained. More than a hundred such derivatives have been prepared and tested in our laboratory. It is interesting to note that the new mildew-proofing agents contain the structure  present in many plant fungicides (tetramethylthiuram disulphide and the salts of dithiocarbamic acid), as well as a carbonyl group conjugated with an ethylenic linkage, found in another class of fungicides[2].

Uniform strips of dyed herring-bone cotton twill were impregnated with 2 per cent of the fungicide under examination and incubated for two weeks on mineral salts agar with pure cultures of *Aspergillus niger* and *Chætomium globosum*. Other such strips were buried for two weeks or four weeks in soil. In each case the percentage loss in tensile strength was determined.

The majority of the compounds of type II tested were effective in preventing deterioration of the cloth in the pure culture tests (less than 5 per cent loss in tensile strength). Eighteen of the compounds afforded similar protection in the two weeks soil burial test. Under the same conditions cloth strips impregnated with chloranil lost 80 per cent or more of their tensile strength.

In four weeks soil burial tests, the most active five compounds were the 2-thenylidene-, *p*-methylcyclohexylidene-, α-*n*-amylhexylidine-, *o*-methylcyclohexylidene- and *p*-chlorobenzylidene-rhodanines. All these prevented tensile strength losses greater than 25 per cent.

Details of this work, which was supported by a contract with the Medical Division, Chemical Corps, U.S. Army, will be reported elsewhere.

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April 9.

[1] U.S. Patent 1,962,109.
[2] Geiger and Conn, *J. Amer. Chem. Soc.*, **67**, 112 (1945).

Improved Sampling Method for Demonstration of Local Antibodies in the Vagina

IN infections with pathogens of low virulence strictly localized to a few or single organs, it is often difficult, if not impossible, to obtain reliable diagnostic findings by means of tests for antibodies circulating in the blood stream. This holds true in particular if only some parts of a mucous membrane are involved. In such cases, however, it may prove practicable to utilize the local antibody production for diagnostic purposes.

Serological examination of vaginal mucus has been employed by Pierce[1] for the diagnosis of bovine trichomoniasis, and by Stegenga and Terpstra[2] for the diagnosis of vibriosis (due to *Vibrio fœtus*). The local production of antibody has also been used to detect bulls with brucellosis localized to the genitals[3].

The procedure hitherto employed for collection of vaginal mucus by suction with a glass tube is cumbersome as well as time-consuming; besides, it is applicable only to cows with sufficient secretion in the vagina. On the other hand, on account of its great dilution, the usually abundant œstral discharge is less suitable for the demonstration of antibodies. Therefore, this sampling technique is not very serviceable for routine examination.

A gauze tampon (about 15 cm. × 19 cm., weighing 1·1 gm.) placed in the fundus of the vagina will absorb on an average about 3 gm. of secretion, and even when the vagina is 'dry' the tampon will take

up about 1 gm. This rather wide variation has no influence upon the outcome of the routine examinations, and, if desired, corrections for the variation can be made by means of dilution. The fluid absorbed by the tampon can also be used for bacteriological examination.

Technique. A piece of gauze, about 15 cm. × 19 cm., weighing about 1·1 gm., is rolled up, tied with ordinary string and wrapped around the end of a thin stick, while the end of the string is tied around the other end of the stick. This swab is then packed in paper and sterilized. For sampling the secretion in the vagina, the tampon is placed in the fundus, for example, through a speculum or by means of a tube made for this purpose[4]. Then the stick and the speculum are removed. After 20–30 min., the tampon is pulled out by means of the projecting end of the string, the vulva being kept wide open. The sample is placed in a glass tube. The secretion is extracted by 4–6 ml. of distilled water or saline. For the various tests, some of this extract is withdrawn by means of a pipette.

This tampon method has proved serviceable in practice in examinations for the presence of antibodies against *Vibrio fœtus*. It has also proved practicable in this way to demonstrate the presence of complement-binding antibodies against pleuropneumonia-like organisms isolated from the same tampon samples taken from a herd with pronounced post-œstral discharge and difficulties in fertilization. (On examination of the blood serum, Edward[5] was unable to demonstrate any complement fixation with homologous strains.)

It may be possible by means of this technique also to throw some light on the much disputed question in human medicine about the relation between unspecific vaginitis or urethritis and pleuropneumonia-like organisms.

L. Szabó

Laboratory of Hygiene and Bacteriology,
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Copenhagen.
March 14.

[1] Pierce, A. E., *J. Comp. Path.*, **57**, 84 (1947).
[2] Stegenga, Th., and Terpstra, J. I., *Tijds. Diergeneeskunde*, **74**, 293 (1949).
[3] Christensen, N. O., *Acta Path. Microbiol. Scand.*, **25**, 202 (1948).
[4] Jepsen, A., and Vindekilde, Th. (unpublished results).
[5] Edward, D. G., *J. Gen. Microbiol.*, **4**, 4 (1950).

Culex (*Culex*) *torrentium* Martini, a Mosquito New to Great Britain

Fourth instar larvæ and pupæ referable to *Culex* (*Culex*) *torrentium* Martini were taken in some abundance from water-tanks on allotments at Isleworth, Middlesex, by Mr. Bowles, of the Health Department, on June 19 of this year. They were sent for identification, together with emergent adults, to the British Museum. The name *torrentium* is applied provisionally since, as Natvig[1] has pointed out, the synonymy of the group is somewhat obscure and requires further investigation. There can, however, be little doubt that this is the Scandinavian species described by Natvig as *torrentium*.

The principal difference between this species and *C. pipiens* lies in the structure of the phallosome, which is absolutely diagnostic (see diagram). Among external characters the best for diagnostic purposes is the presence in *torrentium*, but not in *pipiens*, of a prealar scale patch at the tip of the sternopleura.

Culex spp. *a*, *c*, *C. torrentium* Martini; *b*, *C. pipiens* Linnæus. *a*, *b*, lateral plates of phallosomes; *c*, side view of thorax; *pa*, prealar scale patch

This character has not previously been applied to the Palæarctic *Culex* but was used very successfully by Edwards[2] in dealing with the Ethiopian species. It is considered that it will almost certainly prove to be reliable. Natvig considers certain small differences in wing venation to be diagnostic. The stem of the upper fork cell is said to be about a quarter to a third the length of the fork itself in *torrentium* and a fifth to a sixth the length of the fork in *pipiens*. In *torrentium* the radio-medial cross vein is said to be placed about twice its length distally to the mediocubital cross vein. In *pipiens* it is said to be about one and a half times its length distal to the mediocubital cross vein. It is not known whether these characters will prove to be constant in British populations.

The Isleworth form is quite strikingly different from *pipiens* with respect to certain colour characters, notably the presence in most specimens of far more numerous dark scales on the abdominal sternites. It is, however, a very dark form as compared with topotypic specimens from Thuringia in the British Museum and, as dark and light forms are extremely common in the genus *Culex*, colour differences are of doubtful value. It exhibits numerous pale scales on the underside of the male palps, as does the Scandinavian form, but these would probably be much less conspicuous in a light variety. A few small larval differences are given by Martini[3], who refers to *torrentium* under the name *exilis* Dyar. These may or may not prove constant.

It is not known whether *C. torrentium* bites man; but many members of the *pipiens* group do so. The normal breeding places are fresh natural waters of various kinds; but Natvig has a record—comparable with the present one except that in his case the water was very foul—from a garden pail. It is not known whether this is a recent introduction into Great Britain or whether the species has previously escaped detection owing to its resemblance to *pipiens*. The former explanation is thought to be more probable. If this is a rare, though established, species, it is possible that its detection may have been due to a local increase in population arising from some unusual chain of favourable climatic conditions. In either event it seems desirable to direct attention to its presence in Britain, so that a search may be made for it in other localities.

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British Museum (Natural History),
Cromwell Road,
London, S.W.7.
June 23.

[1] Natvig, L. R., *Norsk entom. Tidsskr.*, Supp. 1 (1948).
[2] Edwards, F. W., "Mosquitoes of the Ethiopian Region", **3** (1941).
[3] Martini, E., in Lindner, "Die Fliegen", **3**, 11, 12 (1931).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN THE ELECTRICAL ENGINEERING DEPARTMENT (industrial experience on the power side of electrical engineering is essential)—The Secretary of University Court, The University, Glasgow (August 7).

DEPUTY MECHANICAL ENGINEER (with a university degree in Engineering, or corporate membership of either the I.C.E., I.M.E., or I.E.E.)—The Engineer and Manager (General), Sunderland and South Shields Water Company, 29 John Street, Sunderland (August 10).

DEVELOPMENT ENGINEER in the Production Department at London headquarters—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/359 (August 11).

LECTURER IN PHYSICS—The Secretary, Royal Technical College, George Street, Glasgow, C.1 (August 11).

SCIENTIFIC OFFICER (Physicist with interest in aerodynamics or Mathematician prepared to do experimental work, with a first- or second-class honours degree or equivalent qualification) for theoretical and experimental duties in connexion with marine aircraft performance, etc. (Ref. 199/51A), and an EXPERIMENTAL OFFICER (with H.N.C. or equivalent qualification in electrical or telecommunications engineering, preferably with experience in the design and maintenance of aircraft electrical systems) (Ref. D.316/51A), at a Ministry of Supply experimental establishment in Suffolk—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (August 11).

SOIL RESEARCH OFFICER in the Irrigation Branch, Punjab Public Works Department, Lahore—The High Commissioner for Pakistan, 35 Lowndes Square, London, S.W.1 (August 13).

ASSISTANT ADVISORY OFFICER (Grade IVa or IVb) IN THE BACTERIOLOGY DEPARTMENT, an ASSISTANT ADVISER IN HORTICULTURE, and a FRUIT TRIALS OFFICER (Grade III or IVb) IN THE HORTICULTURE DEPARTMENT—The Secretary, North of Scotland College of Agriculture, 4½ Union Street, Aberdeen (August 15).

LECTURER IN PHYSICS (preferably in Experimental Physics) at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (August 15).

PSYCHOLOGICAL ASSISTANT in the Department of Psychiatry—The Registrar, The University, Leeds 2 (August 15).

SENIOR EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER IN THE ROYAL NAVAL SCIENTIFIC SERVICE—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4048/51 (August 16).

SENIOR SCIENTIFIC OFFICERS (2, with a first- or second-class honours degree in botany and well qualified in systematic botany) at the Royal Botanic Garden, Edinburgh—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4046/51 (August 16).

CHEMISTS II (Ref. F.492/51A) with first- or second-class honours degree in chemistry or chemical engineering, or associateship of the R.I.C. or I.C.E., and CHEMISTS III (Ref. F.493/51A) with first- or second-class honours degree in chemistry or associateship of the R.I.C., preferably with specialization in organic chemistry and wide industrial experience, in the Ministry of Supply—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (August 18).

JUNIOR PHYSICAL CHEMIST (with at least two years research experience in physical chemistry, and a first- or second-class honours degree) at the I.C.T.A., Trinidad—The Secretary, Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (August 18).

LECTURER IN MATHEMATICS AT THE UNIVERSITY OF SYDNEY—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 18).

RESEARCH OFFICER (Biologist) at the Fisheries Research Station, Dunwich, Queensland, to assist in the programme of research on mullet and oysters (Ref. No. 3469), and an OFFICER-IN-CHARGE, Physical and Mechanical Testing Laboratory, Division of Building Research, Highett, near Melbourne, to undertake and supervise research on physical problems associated with building materials and buildings generally, and to be responsible for physical and mechanical tests on a wide range of building materials (Ref. No. 3470)—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (August 18).

JUNIOR RESEARCH FELLOWSHIP in the study of hydraulics by means of scale models—The Secretary, The University, Aberdeen (August 20).

PHYSICIST or ELECTRICAL ENGINEER (Principal Scientific Officer grade) with a high-class honours degree, and research experience in telecommunications with special emphasis on all radio telephony methods and high speed telegraphy, a PHYSICIST (Senior Scientific Officer grade) with a high-class honours degree, with research experience and a considerable knowledge of electronic circuitry, and a PHYSICIST or ELECTRICAL ENGINEER (Senior Scientific Officer grade) with a high-class honours degree, and experience in telecommunication research with emphasis on radio telephony and high speed telegraphy problems, in the Royal Naval Scientific Service—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4049/51 (August 23).

PHYSICISTS (Scientific Officer grade) (with a first- or second-class honours degree in physics, and experience in optical and photographic work, preferably using high-speed cameras) at a Ministry of Supply design establishment near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.188/51A (August 24).

PHYSICISTS at a Ministry of Supply research establishment near London, for work connected with the handling and measurement of radioactive materials and associated health physics problems—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.200/51A (August 24).

ASSISTANT DIRECTOR (ENGINEERING) AT THE ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL, to be responsible to the Chief Engineer for direction and management of large drawing office and particularly of large engineering workshop engaged in the manufacture of wide variety of experimental plant, mostly to high standards of precision—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.417/51A (August 25).

LECTURER (graduate, with professional experience) IN CIVIL ENGINEERING—The Registrar, King's College, Strand, London, W.C.2 (August 25).

OPERATIONAL RESEARCH POSTS IN THE FIELD INVESTIGATION GROUP OF THE DIRECTORATE OF SCIENTIFIC CONTROL—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/361 (August 25).

ASSISTANT CHEMIST (with a specialized honours degree, or the A.R.I.C. qualification) IN THE DEPARTMENT OF GEOLOGICAL SURVEY—The Secretary, Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (August 31).

ASSISTANT LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY AND CHEMISTRY, to teach inorganic and physical chemistry to first M.B. standard—The Dean, Guy's Hospital Medical School, London Bridge, London, S.E.1 (August 31).

JUNIOR FELLOW (with veterinary qualifications, and postgraduate experience in the subject would be an advantage) IN CLINICAL PARASITOLOGY IN THE VETERINARY SCHOOL—The Registrar and Secretary, The University, Bristol (August 31).

LECTURER or SENIOR LECTURER IN MECHANICAL ENGINEERING AT THE UNIVERSITY OF MELBOURNE—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 31).

PROFESSIONAL ENGINEERS, General Service Class (Main and Senior grades) IN THE ADMIRALTY—The Secretary, Civil Service Commission, Trinidad House, Old Burlington Street, London, W.1, quoting S.86/51 (August 31).

PLANT PHYSIOLOGIST (well qualified in botany, with specialization in plant physiology) at the Wattle Research Institute, University of Natal, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 15).

ASSISTANT LECTURER (probationary) IN APPLIED MATHEMATICS, and an ASSISTANT LECTURER (temporary) IN PHILOSOPHY—The Registrar, University College, Singleton Park, Swansea.

ASSISTANT LECTURER AND DEMONSTRATOR IN THE PHYSIOLOGY DEPARTMENT—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

CIVIL ENGINEERS, Main Grade (Ref. E.251/51) and ASSISTANT CIVIL ENGINEERS, Recruitment Grade (Ref. E.252/51), in the Directorate General of Works, Air Ministry, in London and the Provinces—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No.

CIVIL, MECHANICAL AND ELECTRICAL ENGINEERS for National Defence Projects and developmental works in all States of the Commonwealth and in New Guinea—The Public Service Board Representative, Australia House, Strand, London, W.C.2.

DEMONSTRATOR FOR ELECTRICAL ENGINEERING, and DEMONSTRATORS (2) FOR MECHANICAL ENGINEERING including (*a*) strength of materials, metallurgy and desirably metrology and (*b*) applied thermodynamics and mechanics of fluids with preferably aerodynamics—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants.

ELECTRICAL ENGINEER (Mechanical) by the Central Electricity Board, Federation of Malaya—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.28370.B.

EXPERIMENTAL OFFICER (male) to assist in hydrographic research and chemical analysis of sea-water—The Director, Marine Station, Millport, Isle of Cumbrae.

GEOLOGIST STRATIGRAPHER with an honours degree in geology (Ref. M.27565.E), and a MARINE BIOLOGIST with an honours degree in zoology and a knowledge of the establishment of marine fisheries (Ref. M.27588.E), in the Falkland Islands Dependencies Survey for service in the Antarctic—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting the appropriate Ref. No.

LECTURER (a degree in electrical engineering is essential) for work on electrical measurements—The Secretary, Royal Technical College, Glasgow, C.1.

LECTURER IN MATHEMATICS—The Clerk, Northern Polytechnic, Holloway, London, N.7.

PHYSICISTS, CHEMISTS or ELECTRICAL ENGINEERS (well qualified, with postgraduate experience) for basic research on the electrical properties of materials, particularly dielectrics—The Director, Electrical Research Association, 5 Wadsworth Road, Perivale, Middx.

PRINCIPAL SCIENTIFIC OFFICER (with a good honours degree in engineering and some research experience) IN THE ENGINEERING DIVISION, to undertake investigation of the problems associated with the mechanical harvesting, handling and processing of underwater seaweed—The Secretary, Institute of Seaweed Research, Inveresk, Midlothian.

SENIOR WATER ENGINEER in the Water Supply and Irrigation Department, Cyprus—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/218.

SOIL CHEMIST (Ref. 4/124), and an ENTOMOLOGIST (Ref. 4/41), in the Research Division of the Ministry of Agriculture, Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, quoting the appropriate Ref. No.

STATISTICIAN (with a good degree in mathematics and some industrial experience)—The Divisional Chief Scientist, N.E. Division, National Coal Board, Roundwood Colliery Offices, Parkgate, Rotherham, Yorks.

TELECOMMUNICATIONS ENGINEERS AND PHYSICISTS (Principal Scientific Officer or Senior Scientific Officer grade) at the Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.158/51A.

UNIVERSITY HONOURS GRADUATE (preferably with a degree in organic chemistry) for training as a microanalyst—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

REPORTS and other PUBLICATIONS

(not included in the Monthly Books Supplement)

Great Britain and Ireland

Scientific Proceedings of the Royal Dublin Society. Vol. 25 (N.S.), No. 16: The Evolution of the Earth's Atmosphere. By J. H. J. Poole. Pp. 201–224. 4*s*. Vol. 25 (N.S.), No. 17: Observations on the Inheritance of Field Resistance to Leaf Roll of Potatoes (Shamrock × Skerry Champion). By Dr. Robert McKay and Dr. Phyllis E. M. Clinch. Pp. 225–234+plates 7–8. 3*s*. 6*d*. (Dublin: Royal Dublin Society, 1951.) [155

Gas at your Service. Pp. 72. (London: Gas Council, 1951.) [155

Ancient Britain: a Map of the Major Visible Antiquities of Great Britain Older than A.D. 1066. North Sheet. 32½ in. × 40½ in. With Foreword, Introduction and Combined Index to North and South Sheets. Pp. 36. South Sheet. 32½ in. × 40½ in. With Foreword, Introduction and Combined Index to North and South Sheets. Pp. 36. (Chessington: Ordnance Survey, 1951.) 6*s*. 9*d*. each. [155

Glencoe and Dalness. Pp. 64. (Edinburgh: National Trust for Scotland, 1951.) 1*s*. [155

Bulletins of the Theory of Differential Periodicity. By G. F. Sleggs. No. 2. Pp. 17–28. (Avoca, Co. Wicklow: The Author, Templelusk, 1951.) [165

Economic Reform Club. A Report on the Cost of Living. Pp. 12. (London: Economic Reform Club, 1951.) 1*s*. [165

London County Council: The Horniman Museum. Catalogue of the Adam Carse Collection of Old Musical Wind Instruments. Pp. 88. (London: Staples Press, Ltd., 1951.) 5*s*. [165

Department of Industry and Commerce: Meteorological Service. Geophysical Publications, Vol. 3, No. 4: The Computation of Atmospheric Pressure at the 8 km. Level of Constant Air Density. By Dr. M. Doporto. Pp. 17. (Dublin: Stationery Office, 1951.) 7*s*. 6*d*. [165

Board of Trade. Report of the Committee on Weights and Measures Legislation. (Cmd. 8219.) Pp. iv+147. (London: H.M. Stationery Office, 1951.) 3*s*. 6*d*. net. [165

The Registrar General's Statistical Review of England and Wales for the Two Years 1946–1947. Text, Vol. 1, Medical. Pp. vi+326. (London: H.M. Stationery Office, 1951.) 6*s*. 6*d*. net. [175

Catalogue of an Exhibition illustrating Prehistoric Man in Health and Sickness. (Published for the Wellcome Historical Medical Museum.) Pp. 56+4 plates. (London: Oxford University Press, 1951.) 2*s*. 6*d*. net. [175

The Study of the Distribution of British Plants: being the Report of the Conference held in 1950 by the Botanical Society of the British Isles. Edited by J. E. Lousley. Pp. 128. (Oxford: Botanical Society of the British Isles, c/o Department of Botany, The University, 1951.) 10*s*. [175

Department of Industry and Commerce: Meteorological Service. Geophysical Publications, Vol. 3, No. 5: On the Systematic Influence in Series of Annual Rainfall Totals. By Prof. L. W. Pollak. Pp. 35. (Dublin: Stationery Office, 1951.) 18*s*. [175

British Glaciological Society. Report on the Snow Survey of Great Britain for the Season 1949–50. By E. L. Hawke and D. L. Champion. Pp. 516–527. (London: British Glaciological Society, c/o Royal Geographical Society, 1951.) 2*s*. 6*d*. [215

Jubilee Book of the National Physical Laboratory. By John Langdon-Davies. Pp. 104+32 plates. (London: H.M. Stationery Office, 1951.) 4*s*. net. [215

U.K. Petroleum Industry; Statistics relating to Consumption and Refinery Production, 1949 and 1950. Pp. 8. (London: Petroleum Information Bureau, 1951.) [215

Proceedings of the Royal Society of Edinburgh. Section A (Mathematics and Physical Sciences). Vol. 63, Part 2, No. 10: The Reciprocity Theory of Electrodynamics. By H. S. Green and K. C. Cheng. Pp. 105–138. 5*s*. 6*d*. Vol. 63, Part 2, No. 11: Application of Relaxation Methods to Compressible Flow past a Double Wedge. By Dr. A. R. Mitchell and Dr. D. E. Rutherford. Pp. 139–154. 2*s*. 6*d*. Vol. 63, Part 2, No. 12: Clebsch–Aronhold Symbols and the Theory of Symmetric Functions. By H. W. Turnbull and A. H. Wallace. Pp. 155–173. 3*s*. Vol. 63, Part 2, No. 13: Studies in Practical Mathematics, 6, On the Factorization of Polynomials by Iterative Methods. By Dr. A. C. Aitken. Pp. 174–191. 3*s*. (Edinburgh and London: Oliver and Boyd, Ltd., 1951.) [215

Institute of Social Medicine. Sixth Annual Report, 1950. Pp. 16. (Oxford: Institute of Social Medicine, 1951.) [215

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Department of Scientific and Industrial Research. Report of the Radio Research Board for the Year 1949. Pp. iv+54. (London: H.M. Stationery Office, 1951.) 1*s*. 9*d*. net. [225

Thirty-first Annual Report of the Board of the Institute of Physics. Pp. 16. (London: Institute of Physics, 1950.) [225

British Drug Houses, Ltd. Report of the Directors for the Year ended 31st December 1950. Pp. 12. (London: British Drug Houses, Ltd., 1951.) [225

Other Countries

World Health Organization. Technical Report Series. No. 31: Expert Committee on Mental Health: Report on the Second Session. Pp. 52. 2*s*. 9*d*.; 35 cents. No. 39: Expert Committee on Malaria; Report on the Fourth Session. Pp. 32. 1*s*. 6*d*.; 20 cents. (Geneva: World Health Organization; London: H.M. Stationery Office, 1951.) [155

Bulletin of Marine Science of the Gulf and Caribbean. Vol. 1, No. 1, March. Pp. 88. (Coral Gables, Fla.: University of Miami Press, 1951.) 2 dollars; 7.50 dollars per Vol. of 4 Nos. [155

Rubber Research Institute of Malaya. Report for the Period September 1945 to December 1948. Pp. ii+295. (Kuala Lumpur: Rubber Research Institute of Malaya, 1951.) [165

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